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(54) DECORATIVE LAMINATED STRUCTURES AND METHOD OF MAKING THE SAME

(71) We, DAI NIPPON PRINTING CO., LTD., a Japanese Company, of No. 1—12, Ichigayakagacho, Shinjuku-ku, Tokyo, Japan,

do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a laminated structure and a method of making the same.

More particularly, this invention is concerned with a decorative laminated structure having on its surface a regular or irregular pattern of concave portions.

There have heretofore been proposed various kinds of decorative laminated structures for use not only in ceilings, floors or walls of buildings cars or ships but also in furniture, fittings, tables, musical instruments, and cabinets. However, many consumers are not satisfied with conventional decorative laminated structures having only a flat and smooth, decorated surface. There has been an increasing demand for a laminated structure which has on its surface a sophisticated and complicated pattern with a three dimensional effect. There have been known laminated structures having a surface with a pattern composed of various shapes of concave portions.

As examples of laminated structures having such patterns composed of concave portions, there have been structures comprising a suitable base layer provided thereon with a pattern of concave surface portions imitating a natural pattern of grains of wood or stone or a pattern of cloth. Such concave portions of the surface are usually formed so as to resemble grooves when the pattern of grain of wood is employed, cracks when a pattern of grains of stone is employed, or yarn when a pattern of cloth is employed. Thus, there have been provided decorative laminated structures whose surfaces are provided with realistic patterns having a good three dimensional effect. In forming the concave portions of the surface of the abovementioned decorative laminated structure, a method generally employed includes the use of a metallic mould roll or metallic mould plate having on its surface a pattern composed of convex portions and which is pressed onto the surface of the laminate so as to form the pattern of grains of wood, stone or cloth, this procedure comprising an embossing process.

For practising such a method, it is necessary to provide a metallic mould roll or metallic mould plate which is expensive to manufacture since it is necessary to use a complicated fabricating technique. Moreover, it is very difficult to make fine and complicated shapes of convex portions on the metallic mould roll or plate and, hence, the pattern of such metallic mould or roll or plate tends inevitably to be of comparatively simple relief design. Consequently, with such a conventional method, it is extremely difficult to make, on the surface of the laminated structure, a pattern of fine and detailed

shapes of concave portions which is required for a realistic three dimensional effect.

Furthermore, it is noted that for practising the method employing a metallic mould roll or plate, the following additional difficulties or disadvantages are encountered:

1) When a different pattern of concave surface portions is desired, it is necessary to prepare another metallic mould roll or plate having a pattern corresponding to the new pattern, leading to a substantially increased cost.

2) When using a metallic mould roll or plate having a pattern of convex portions, it is very difficult to effect an embossing processing while aligning the pattern of convex portions of the metallic mould roll or plate with a pattern which has been previously formed on the surface of the laminated structure. Even slight displacement causes the commercial value of the product to be largely reduced.

3) Since the embossing processing is conducted mechanically and physically by employing a mould or plate made of metal, the surface of the desired decorative laminated structure will frequently be damaged during the processing operation.

The present invention consists in a decorative laminated structure having a pattern of concave surface portions, which comprises: a base layer; a sheet; and, contiguous and directly adhered to said sheet, a masking layer having a plurality of radiant heat-absorbing areas, the concave surface portions being formed on the sheet at its portions covered by the heat-absorbing areas.

The present invention also consists in a method of making a decorative laminated structure having a pattern of concave surface portions which comprises forming a laminated composite material comprising a base layer, a sheet of heat-shrinkable material and a masking layer containing a plurality of heat-absorbing areas, said masking layer being contiguous and directly adhered to said heat-shrinkable sheet; and irradiating the composite material with radiant heat to cause said sheet at its portions covered by said heat-absorbing areas to shrink so as to form concave surface portions.

Preferred embodiments of the invention will be described below with reference to the accompanying drawings, in which:

Fig. 1 shows cross-sectional views showing a process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 2 shows cross-sectional views showing another process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 3 shows cross-sectional views showing still another process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 4 shows cross-sectional views showing a further process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 5 shows cross-sectional views showing a still further process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 6 shows cross-sectional views showing a still further process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 7 shows cross-sectional views showing a still further process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 8 shows cross-sectional views showing a still further process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 9 shows cross-sectional views showing a still further process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 10 shows cross-sectional views showing a still further process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 11 shows cross-sectional views showing a still further process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 12 shows cross-sectional views showing a still further process for manufacturing a laminated composite material to be employed for making a decorative laminated structure according to the present invention;

Fig. 13 shows a cross-sectional view showing a method of making a decorative laminated structure according to this invention by employing the composite material shown in Fig. 1 indicated by arrow *A* therein the resulting surface shape of the structure;

Fig. 14 shows a cross-sectional view showing a method of making a decorative laminated structure according to this invention by employing the composite material shown in Fig. 1 indicated by arrow *B* therein and the resulting surface shape of the structure;

Fig. 15 shows a cross-sectional view showing a method of making a decorative laminated structure according to this invention by

employing the composite material shown in Fig. 11 and the resulting surface shape of the structure;

Fig. 16 shows a cross-sectional view showing a method of making a decorative laminated structure according to this invention by employing the composite material shown in Fig. 12 and the resulting surface shape of the structure

Fig. 17 shows cross-sectional views showing a method of making a decorative laminated structure according to this invention by employing the composite material shown in Fig. 9 indicated by arrow *N* therein and the resulting surface shape of the structure;

Fig. 18 is a perspective view of one form of a decorative laminated structure according to the present invention, with two edges shown in cross-section;

Fig. 19 is a perspective view of another form of a decorative laminated structure according to the present invention, with two edges shown in cross section;

Fig. 20 is a perspective view of still another form of a decorative laminated structure according to the present invention, with two edges shown in cross section;

Fig. 21 shows a cross-sectional view showing one method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 22 shows a cross-sectional view showing another method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 23 shows a cross-sectional view showing still another method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 24 shows a cross-sectional view showing a further method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 25 shows a cross-sectional view showing still another method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 26 shows a cross-sectional view showing still another method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 27 shows a cross-sectional view showing still another method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 28 shows cross-sectional views showing still another method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 29 shows cross-sectional views showing still another method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 30 shows cross-sectional views showing still another method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 31 shows a cross-sectional view showing a still further method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 32 shows a cross-sectional view showing a still further method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 33 shows a cross-sectional view showing a still further method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 34 shows a cross-sectional view showing a still further method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 35 shows a cross-sectional view showing a still further method of making a decorative laminated structure according to the present invention and the resulting surface shape of the structure;

Fig. 36 shows cross-sectional views showing a still further method of making a decorative laminated structure according to the present invention, and a diagrammatic plan view showing a process for heat-fixation of the sheet of heat-shrinkable material;

Fig. 37 shows a cross-sectional view showing a still further method of making a decorative laminated structure according to the present invention and a side view showing a process for irradiating the composite material with radiant heat; and

Fig. 38 shows a cross-sectional view showing a still further method of making a decorative laminated structure according to the present invention, a plan view of an apparatus for irradiating the composite material with heat rays to shrink the sheet of heat-shrinkable material and to effect heat-fixation of the sheet and a perspective view of a cabinet made of a decorative laminated structure of the present invention.

Essentially, according to the present invention, there is provided a decorative laminated structure having a pattern of concave surface portions which comprises a laminated composite material including a base layer, a sheet of material and a masking layer con-

taining a plurality of heat-absorbing areas contiguous and directly adhered to said sheet, the concave portions being formed on said sheet at its portions covered by said heat-absorbing areas. Such a decorative laminated structure can be obtained by forming a laminated composite material comprising a base layer, a sheet of heat-shrinkable material, which sheet may be referred to hereinafter as a "heat-shrinkable sheet", and a masking layer containing a plurality of heat-absorbent areas to form a laminated composite material, said heat-absorbent areas being contiguous to and closely adhered to said heat-shrinkable sheet; and irradiating the composite material with radiant heat to cause said heat-shrinkable sheet at its portions covered by said heat-absorbing areas to cave in, thus forming concave portions.

Referring now to Figs. 1 to 12, there are shown various processes for manufacturing a laminated composite material to be used for making a decorative laminated structure according to the present invention. Essentially, as described before, the composite material comprises a base layer, a heat-shrinkable sheet and a masking layer containing a plurality of heat-absorbing areas contiguous to and closely adhered to said heat-shrinkable sheet. According to the present invention, there may be employed various forms of assembly, which will be apparent from the following description.

In Fig. 1, on a surface *a* of a heat-shrinkable sheet 1 is formed a masking layer 4 consisting of heat-absorbent areas 2 and heat insensitive areas 3. Subsequently, according to the process shown by arrow *A*, a base layer 5 is laminated to the back *b* of the heat-shrinkable sheet to form a composite material. Alternatively, according to the process shown by an arrow *B*, a base layer 5 is laminated on the surface of the masking layer 4 on the heat-shrinkable sheet 1.

In Fig. 2, on a base layer 5 is formed a masking layer 4 consisting of heat sensitive areas 2 and heat-absorbing areas 3. Subsequently, according to the process shown by an arrow *C*, a heat-shrinkable sheet 1 is laminated on the surface of the masking layer 4 on the base layer 5.

In Fig. 3, on one face of a heat-shrinkable resin sheet 1 are formed heat-absorbing areas 2, and on the other face of the heat-shrinkable sheet 1 are formed non-heat-absorbing areas 3 corresponding to the gaps between the heat-absorbing areas 2. Subsequently, according to the process shown by arrow *D*, a base layer 5 is laminated to the surfaces of the heat-absorbing areas 2 on the heat-shrinkable sheet 1. Alternatively, according to the process shown by an arrow *E* a base layer 5 is laminated to the surfaces of the non-heat-absorbing areas 3 on the heat-shrinkable areas 1.

In Fig. 4, heat-absorbing areas 2 are formed on a heat-shrinkable sheet 1, while non-heat-absorbing areas 3 corresponding to the gaps between the heat-absorbing areas 2 are formed on a base layer 5. Subsequently, according to the process shown by an arrow *F*, the face *c* of the heat-shrinkable sheet on which there are no heat-absorbing areas 2 is laid on the faces of the non-heat-absorbing areas 3 on the base 5 to form a composite material. Alternatively, according to the process as shown by an arrow *G*, laminating is effected in such a manner that the heat-absorbing areas 2 on the heat-shrinkable sheet 1 cooperate with the non-heat-absorbing areas 3 on the base 5 to form a complete masking layer 4, as depicted.

In Fig. 5, heat-absorbing areas 2 are formed on a base layer 5, while non-heat-absorbing areas 3 corresponding to the gaps between the heat-absorbing areas 2 are formed on a heat-shrinkable sheet 1. Subsequently, according to the process shown by an arrow *H*, the face *d* of the heat-shrinkable sheet 1 on which there are no non-heat-absorbing areas 3 is laid on the faces of the heat-absorbing areas 2 on the base layer 5 to form a composite material. Alternatively, according to the process shown by an arrow *I*, laminating is effected in such a manner that the non-heat-absorbing areas 3 on the heat-shrinkable sheet 1 cooperate with the heat-absorbing areas 2 on the base layer 5 to form a complete masking layer 4, as depicted.

In Fig. 6, a heat-shrinkable sheet 1 is laminated on a base layer 5. Subsequently, according to the process shown by an arrow *J*, on the thus laminated heat-shrinkable sheet 1 is formed a masking layer 4 consisting of to a base layer 5, whereupon non-heat-absorbing areas 3 to form a composite material thereby.

In Fig. 7, heat-absorbing areas 2 are formed on a heat-shrinkable sheet 1. Subsequently, according to the process shown by arrows *K* and *K'*, the heat-shrinkable sheet 1 with its lower face *e* on which the heat-absorbing areas 2 are not formed is laminated to a base layer 5, whereupon no-heat-absorbing areas 3 are formed on the upper face of the heat-shrinkable sheet 1 so as to form a complete masking layer 4, as depicted. Alternatively, according to the process shown by arrows *L* and *L'*, the heat-shrinkable sheet 1 with its upper face *e* on which the heat-absorbing areas are not formed is laminated on a base layer 5, whereupon non-heat-absorbing areas 3 corresponding to the gap between the heat-absorbing areas 2 are formed on said upper face *e*. Moreover, although not shown in Fig. 7, on the heat-shrinkable sheet 1 may be first formed the non-heat-absorbing areas 3 in place of the heat-absorbing areas 2. Subsequently, the heat-shrinkable sheet 1

is laminated on a base layer 5, whereupon the heat-absorbing areas 2 are formed.

In Fig. 8, heat-absorbing areas 2 are formed on a base layer 5. Subsequently, according to the process shown by arrows *M*, *M'*, a heat-shrinkable sheet 1 is laid on the base 5 with its upper face on which the heat-absorbing areas 2 are formed, whereupon non-heat-absorbing areas 3 are formed on the heat-shrinkable sheet 1. Although the non-heat-absorbing areas 3 should, as repeatedly described hereinbefore, correspond to the gaps between the heat-absorbing areas 2, the recitation to that effect will be hereinafter omitted so as to avoid repetition. In a similar manner as explained in connection with Fig. 7, though not shown in Fig. 8, on the base layer 5 may be first formed the non-heat-absorbing areas 3 in place of the heat-absorbing areas 2. Subsequently, the base layer 5 is laminated on a heat-shrinkable sheet, whereupon the heat-absorbing areas 2 are formed.

In any of the processes as mentioned above, the masking layer 4 consists of heat-absorbing areas 2 and non-heat-absorbing areas 3. However, according to the present invention, the masking layer 4 may consist of only heat-absorbing areas 2. For example, as shown in Fig. 9, heat-absorbing areas 2 are formed on a heat-shrinkable sheet 1. Subsequently, according to the process shown by an arrow *N*, the heat-shrinkable sheet 1 with its lower face *f* on which the heat-absorbing areas 2 are not formed is laid on a base layer 5 to form a composite material. Alternatively, according to the process shown by an arrow *O*, the heat-shrinkable sheet 1 with its upper face *f* on which the heat-absorbing areas 2 are not formed is laid on a base layer 5 to form a composite material. In addition, as shown in Fig. 10, heat-absorbing areas 2 are formed on a base layer 5. Subsequently, according to the process shown by an arrow *P*, a heat-shrinkable sheet 1 is laid on the face of the base layer 5 i.e. that on which the heat-absorbing areas 2 are formed.

Furthermore, according to the present invention, the heat-shrinkable sheet of the composite material may have on its exposed face a coating for regulating the gloss or lustre of the surface of the composite material or for protecting the surface of the same. For example, the manner of applying such a coating to the composite material will be explained hereinbelow with reference to the composite material shown in Fig. 1. As shown in Fig. 11, a coating 6 is formed on the heat-shrinkable sheet 1 over the masking layer 4. Alternatively, as shown in Fig. 12, a coating 6 is formed directly on the heat-shrinkable sheet 1.

The above-mentioned processes are given only as illustrations of processes for manufacturing a composite material which can be employed for making a decorative laminated structure.

The heat-shrinkable sheet to be employed for making a composite material may be any heat-shrinkable plastics sheet. Examples of such heat-shrinkable plastics sheets are sheets of thermoplastic homopolymers or copolymers such as polyvinyl chloride, polyvinylidene chloride, polyolefins including, for example, polyethylene and polypropylene, polystyrene, polyesters, polyamides, polycarbonate polyvinyl alcohol. Cellulosic materials or rubber materials may also be used. Of the above-mentioned materials, there are preferably employed sheets which have been subjected to a uniaxial or biaxial stretching at the optimum temperature for stretching and then not subjected to any treatment for thermal fixation or subjected to insufficient treatment for thermal fixation to retain a heat-shrinkable property. Thin sheets are often referred to as "films" in the art. The term "sheet" used herein is intended to include such films.

The heat-shrinkable thermoplastic sheet may be transparent or opaque, uncoloured, coloured, or may contain fillers, or may have a coarse surface provided by grains of sand and the like for delustering the surface, as far as it is heat-shrinkable.

The properties of the heat-shrinkable sheet, such as rate of heat-shrinkage, direction of stretching, heat-shrinkage-initiating temperature, shrinking force, and thickness influence the depth and size of the concave portions formed on the heat-shrinkable sheet, but are not critical for the present invention. As described above, as long as the sheet is heat-shrinkable, it can be used in the method of this invention. Illustratively stated, when the rate of shrinkage of the heat-shrinkable sheet is low, the concave portions formed on such a resin sheet are shallower and smaller. The depth and size of the concave portions on the heat-shrinkable sheet can, however be appropriately regulated by increasing the intensity of the radiant heat. Moreover, when a heat-shrinkable sheet having a high shrinkage-initiating temperature is used, the concave portions formed on such a resin sheet are comparatively shallow and small. The depth and size of the concave portions on the heat-shrinkable sheet can, however, be appropriately regulated by increasing the intensity of the radiant heat.

The base layer may be made of any known material capable of laminating to the heat-shrinkable sheet. Examples of suitable materials to be used for making the base layer include various kinds of papers; Cellophane (Trade Mark); sheets of acetate resins, polyolefins such as polyethylene and polypropylene, polyvinyl chloride, polyviniylidene chloride, polystyrene, polycarbonate, polyvinyl alcohol, polyamides, and polyesters; metallic plates and foils, wooden sheets and

plywoods; rubber sheets; and assemblies made by laminating any combination of them together in accordance with known methods. The base materials may be transparent or opaque, uncoloured, or coloured.

The term "heat-absorbing area" is used herein to mean an area formed with a composition containing a heat absorbing material having a relatively good absorbability of radiant heat when the heat absorbing material is irradiated therewith. The term "non-heat-absorbing area" is used herein to mean an area formed with a ink composition containing a material having a relatively poor absorbability of radiant heat, as compared with said heat absorbing material, when the heat absorbing material is irradiated with radiant heat. In this connection, it is to be noted that whether the material is "heat-absorbing" or "non-heat-absorbing" is determined depending upon difference in respect of heat sensitivity between the one material and the other.

The masking layer containing a plurality of heat-absorbing areas may comprise only the heat-absorbing areas or may comprise the heat-absorbing areas and the non-heat-absorbing areas. For example, with reference to a decorative laminated structure having a wood grain pattern or a stone pattern, the structure comprises the heat-absorbing areas forming concave surface portions in the form of grooves and the non-heat-absorbent areas forming the remaining portions.

In making the masking layer containing at least the heat-absorbing areas, only the heat-absorbing areas or both of the heat-absorbing areas and the non-heat-absorbing areas corresponding to the gaps between the heat-absorbing areas are formed on the heat-shrinkable sheet and/or the base prior to or after assembling the heat-shrinkable sheet and the base with each other.

As a method for forming the heat-absorbing areas or both the heat-absorbing areas and the non-heat-absorbing areas on the heat-shrinkable sheet and/or the base layer, there may be employed a photogravure printing, offset printing, relief printing, screen printing, electrostatic printing or transfer printing; hand painting by a pen or brush. Alternatively, pre-formed heat-absorbing areas or both pre-formed heat-absorbing areas and pre-formed non-heat-absorbing areas may be pasted on the heat-shrinkable sheet and/or the base layer. It is necessary to employ a heat-absorbing ink composition containing a heat-absorbing material or both of such a heat-absorbing ink composition and a non-heat-absorbing ink composition containing a material having a relatively poor absorbability of radiant heat as compared with said heat-absorbing material.

The printing may be monocolour or multi-colour printing. Differently stated, any printing may be employed as long as the heat-absorbing areas or the heat-absorbing areas together with the non-heat-absorbing areas form a desired pattern such as a wood grain pattern, a stone pattern or a fabric pattern.

In forming the heat-absorbing areas or both the heat-absorbing areas and the non-heat-absorbing areas on the heat-shrinkable sheet and/or the base, suitable preliminary treatment may be applied to the surface of the heat-shrinkable sheet and/or the base, if desired. For example, the surface may first be washed, ground or coated.

Both the heat sensitive ink composition containing the heat-absorbing material and the heat insensitive ink composition containing a material having a relatively poor absorbability of radiant heat as compared with said heat absorbing material is generally an ink composition or a paint composition which comprises a vehicle; or colouring material such as a dye or pigment; and additives such as a plasticizer, a stabilizer, a wax-grease, a dryer, an auxiliary dryer, a hardening agent, a thickening agent, a dispersing agent and/or a filler; said vehicle, said colouring material and said additives being well blended using a solvent and/or a diluent.

Examples of the vehicles to be employed for the ink or paint composition include fats and oils such as linseed oil, soybean oil, and synthetic drying oils; natural and processed resins such as rosin, copal, dammar, hardened rosin, rosin esters, and polymerized rosin; synthetic resins such as a rosin modified resin, a 100% phenolic resin, a maleic acid resin, an alkyd resin, a petroleum type resin, a vinyl resin, an acrylic resin, a polyamide resin, an epoxy resin or an aminoalkyd resin; cellulose derivatives such as nitrocellulose or ethylcellulose; rubber derivatives such as rubber chloride and cyclized rubber; glue; casein; dextrin and zein.

The term "heat sensitive ink composition" is used herein to mean an ink or paint composition which is capable of forming a film coating having a high rate of absorption of radiant heat. The term "heat insensitive ink composition" is used herein to mean an ink or paint composition forming a film coating having a low rate of absorption of radiant heat. In short, whether the ink composition is "heat sensitive" or "heat insensitive" is determined depending on the relative difference in its rate of heat ray absorption.

Similarly, the term heat-absorbing material means a material, for example a colouring material such as a dye or pigment, which has a high rate of radiant heat-absorption. Whether the material is heat-absorbing or a poor heat-absorber is determined depending on the relative difference in its rate of radiant heat-absorption. Illustratively stated, the rate of radiant heat-absorption of a black colour-

ing material is generally about 90%; that of a green, light brown, gray or blue colouring material about 65—75%; that of a red colouring material about 65%; that of a light green colouring material about 55%; that of a creamy colouring material about 45%; and that of a white colouring material about 35—40%. The above values are well known, and obtained on the basis that the rate of radiant heat-absorption of an ideal black body is 100%.

For forming a heat-shrinkable sheet—base laminate of the composite material to be employed in the present invention, there may be employed any of various conventional methods, for example an adhesive lamination method wherein an adhesive is coated on the heat-shrinkable sheet and/or the base and then the sheet and the base are adhered to each other, utilizing pressure e.g. a pressing roll; a heat lamination method or a high frequency lamination method. The adhesives may be those well known in the art and include, for example adhesives containing as a main component an acrylic resin, a vinyl resin, a polyamide resin, a cellulosic material, aminoplast resin, a phenolic resin, a polyester resin, a furan resin, an epoxy resin, a polyurethane resin or a rubber. The above-mentioned adhesives may be, for example, an emulsion type adhesive, a solvent sensitive adhesive, or an impact adhesive.

In making the heat-shrinkable sheet-base laminate, there may be applied, to the surface of the heat-shrinkable sheet and/or the surface of the base, a suitable known pre-treatment such as a treatment for rendering the surface flat and smooth by grinding or pre-coating.

In applying a coating layer onto the composite material to be used in the method of this invention, there may be employed an ordinary coating method such as roll coating, gravure coating, bar coating, flow coating, dip coating or spray coating, using a resin composition obtained by well blending a resin, a filler and a solvent; or a lamination method wherein a film or sheet of resin is laminated to the composite material by a conventional method such as an adhesive lamination or heat-fusion lamination. The resins usable in the above include, for example, natural or processed resins; synthetic reins such as an alkyd resin, a butylated aminoaldehyde resin, a phenolic resin, a vinyl resin, an acrylic resin, an epoxy resin, a polyurethane resin or a butyral resin; cellulose derivatives such as nitrocellulose, celluloseacetate, and butylcellulose; or a rubber derivative. The films or sheets of resin useable to be employed in the above include, for example, those of a resin such as polyethylene, polypropylene, a polyester, polyvinylidene chloride, polystyrene, polycarbonate, polyvinyl alcohol or a polyamide. As the fillers, there may be used titanium dioxide, alumina, gypsum, silica, calcium carbonate, barium sulfate or clay.

As described, a composite material is easily obtained which comprises a base layer, a heat-shrinkable resin sheet and a masking layer containing a plurality of heat-absorbing areas contiguous to and closely adhered to said heat-shrinkable sheet.

According to the method of the present invention, the thus obtained composite material is irradiated with radiant heat to cause the heat-shrinkable sheet at its portions corresponding to said heat-absorbing areas to cave in, thus forming a pattern of concave and convex portions. Thus, there can be obtained a decorative laminated structure having on its surface a pattern of concave and convex portions.

Referring now to Fig. 13 in which there is illustrated a method of making a decorative laminated structure according to this invention by employing the composite material of Fig. 1 process *A* and the resulting surface shape of the structure. When the composite material is irradiated with radiant heat 7, the portions of the heat-shrinkable sheet 1 corresponding to heat-absorbing areas 2 cave to form concave portions 8. As a result of this, there is obtained a decorative laminated structure having a surface with concave portions 8 having a relief determined by the heat-absorbing areas 2.

Referring to Fig. 14 in which there is shown a process similar to that of Fig. 13, using a composite material of Fig. 1 process *B*. When the composite material is irradiated with radiant heat 7, portions of the heat-shrinkable sheet 1 corresponding to heat sensitive areas 2 cave in, thereby forming concave portions 9. As a result, a decorative laminated structure of this invention is obtained. In Fig. 15 is shown a similar process to Fig. 13, employing the composite material of Fig. 11.

As shown in Fig. 16, when the composite material of Fig. 12 is employed, the irradiation of the composite material with radiant heat 7 causes the portions of the heat-shrinkable sheet 1 corresponding to the heat-absorbing areas 2 and the overcoat layer 6 to cave in, thereby forming a decorative laminated structure having on its surface concave portions 11.

As apparent from the above description, when heat-absorbing areas are formed on the exposed surface of the heat-shrinkable sheet of the assembly, the irradiation of the assembly with radiant heat causes both the portions of the heat-shrinkable sheet corresponding to the heat-absorbing areas and the heat-absorbing areas to cave in, thereby forming concave portions which are coloured with the colour of the heat-absorbing areas. On the other hand, when the heat-absorbing areas are formed between the heat-shrinkable

sheet and the base, the irradiation of the composite material with radiant heat causes only the portions of the heat-shrinkable sheet corresponding to the heat-absorbing areas to cave in, thereby forming concave portions. Furthermore, when a coating layer is formed on the assembly, the coating layer also caves in with the heat-shrinkable sheet, thereby forming concave portions.

Although not shown, the irradiation of the assembly of each of Figs. 2 to 10 with radiant heat also causes concave portions in the heat-shrinkable sheet in the substantially same manner as described above, thus producing a decorative laminated structure having on its surface a pattern of concave and convex portions according to the present invention.

As shown in Fig. 17, when the assembly of Fig. 9 process *N* is employed having a masking layer containing only heat-absorbing areas, the composite material is irradiated with a radiated heat to cause the heat-shrinkable sheet to cave in whereby concave portions 12 are formed, and subsequently non-heat-absorbing areas 3 coordinating with said concave portions 12 are provided. Thereby, there can be obtained a decorative laminated structure having on its surface a pattern of concave and convex portions according to the present invention.

In Figs. 15 and 16, a composite material with a coating layer thereon is irradiated with radiant heat to obtain a laminated structure with the coating layer thereon. Alternatively, as shown in Figs. 13 and 14, an assembly without the coating layer is irradiated with the radiant heat to form a laminated structure with the concave portions on its surface, whereupon the laminated structure may be provided, on its surface, with a coating layer to obtain a laminated structure having a coating layer.

In carrying out irradiation of the assembly with radiant heat, infrared radiation is most preferably employed. As a source of the infrared radiation, there may be employed, for example a filament lamp, a discharge lamp, an arc lamp. Heat is transmitted to the assembly by radiation from such a lamp.

For effecting a selective heating by utilizing a difference in rate of heat absorption between the heat-absorbing areas and the non-heat-absorbing areas, it is preferable to employ infrared radiation having a short wave length. A source capable of radiating near infrared radiation (wave length: about 0.8—2.5 μ) having a peak of spectral distribution at a wave length of about 1.0 μ is preferably employed. In practice, there may be employed an ordinary tungsten filament lamp, a tungsten filament lamp containing a halogen gas or a xenon lamp. Also, even a commercially available heating type copying machine can be used.

In irradiating the assembly with radiant heat, when the exposure dose is too much, the elevation in temperature of the heat-absorbing areas becomes too high. As a result of this, the heat-shrinkable sheet is caused not only to cave in but also to be heat-fused, leading to cutting and/or formation of internal cavities with disadvantage.

The irradiation may be effected from any direction relative to the assembly. However, the base may be non-conducting. Therefore, it is preferable to directly irradiate the heat-shrinkable sheet.

The size and depth of the concave portion formed on the heat-shrinkable sheet by the irradiation depending on various factors including, for example, type rate of shrinkage, and thickness, of the heat-shrinkable sheet; hue, concentration, and area of the heat-absorbing areas; exposure dose, of, and exposure time to the radiation. It is thus necessary to choose appropriate conditions for each case. Yet, in this connection, it should be noted that, of the above-mentioned various factors, the hue, concentration, and area of the heat-absorbent areas have the greatest influence on the size and depth of the concave portion to be formed in the surface of the heat-shrinkable sheet.

As described, according to the present invention, when the assembly is irradiated, the heat-absorbing areas in the masking layer containing at least the heat-absorbing areas are heated to a high temperature, as compared with the non-heat-absorbing areas, if any. As a result, there is caused a difference in rate of thermal shrinkage of the heat-shrinkable sheet, to wit, the portions corresponding to the heat-absorbing areas shrink more than the other areas, resulting in the formation of concave areas.

The thus obtained decorative laminated structure contains the heat-shrinkable sheet having concave portions formed locally at its portions corresponding to the heat-absorbing areas. Yet, the heat-shrinkable sheet has, at its said other areas, a still remaining heat-shrinkability and hence; when such decorative laminated structure is heated to a temperature higher than the shrinkage-initiating point of the heat-shrinkable sheet, such sheet under-goes heat shrinkage, resulting in bending or folding of the laminated structure. In order to obviate such drawbacks, the laminated structure may be subjected to a treatment for heat stabilisation while holding the peripheral edges of the structure, to improve the heat stability of the present decorative laminated structure. For example, to heat stabilise the present decorative laminated structure, the structure is heated, while holding the peripheral edges so as to prevent dimensional change, at a temperature above the shrinkage-initiating point and the second order transition point and below the melting

point, using heated air, a liquid of high temperature, far infrared radiation, or a heating roll. It is preferable to employ a temperature higher than the stretching temperature, and the stabilisation is increased by heating the structure at a temperature as high as possible without allowing melting. The temperature and the heating time are varied depending on the type of heat-shrinkable sheet used. Moreover, it is to be noted that the present structure is a laminate one. For this reason, according to the case, the temperature and time should be appropriately chosen, taking into consideration the types of materials and their thicknesses as well as the intended use of the present laminated structure. In order to hold the peripheral edges to prevent shrinkage of the heat-shrinkable sheet during the heat stabilisation treatment at high temperature, there may be used in apparatus of the design substantially similar to that of an ordinary tenter used for the woven article. Using such apparatus, the present decorative laminated structure is heated while its sides are held by means of a plurality of clips having a width of about 2—5 cm. Alternatively, the heat stabilisation of the structure may be effected employing a heating roll utilizing, as a heat source, electricity or steam. In such case, when the area of the laminated structure wound on the heating roll is increased, the dimensional change of the structure is automatically avoided due to frictional force between the roll and the structure, thereby enabling use of the clips to be eliminated.

By effecting the above-mentioned heat stabilisation treatment, the remaining heat-shrinkability of the heat-shrinkable sheet can be obviated and, at the same time, the shapes of the concave portions is unchanged. Yet, it is desirable to avoid the use of too high a temperature. In practice, for example, when a heat-shrinkable polyester resin film having a thickness of 12 μ and a shrinkage rate of 40% at 100°C. is heated, while holding the peripheral edges of the film, at a temperature of 240°C. for 20 seconds using hot air, the film is heat-stabilised to a shrinkage rate of 1% at 100°C. Also, when a polyvinyl chloride resin film having a thickness of 40 μ and a heat shrinkage rate of 25% at 100°C is passed, while holding its peripheral edges, through a heating furnace with four 200 V ultra-far infrared heaters (i.e. heaters emitting infrared radiation of wavelengths in the part of the spectrum immediately adjacent the microwave region) each having an irradiation intensity of 10 W/cm for 4 seconds, the film is heat-stabilised to a shrinkage rate of 3% at 100°C.

As described, according to the present invention, when the composite material which comprises a heat-shrinkable resin sheet a base layer and a masking layer containing at least a plurality of heat-absorbing areas contiguous and closely adherent to said heat-shrinkable sheet is irradiated with radiant heat, the heat-shrinkable sheet is caused, at its portions corresponding to the heat-absorbing areas, to cave in, thereby forming concave portions varied in size and depth depending on temperature differences due to the varied rates of heat absorptions of the heat-absorbing areas distributed in the masking layer. Thus, there can be obtained a decorative laminated structure having on its surface a pattern of concave and convex portions and which is strong and durable, attractive and realistic, particularly in its three dimensional effect. Furthermore, the heat-absorbing areas are composed of the heat sensitive ink composition and, hence, the resulting concave portions are effectively coloured.

Moreover, it is to be noted that the masking layer containing at least the heat-absorbing areas can be readily made by, for instance, printing to render the pattern composed of the heat-absorbing area fine and delicate. As a result, fine and delicate concave portions can also be made on the heat-shrinkable sheet at its portions corresponding to the heat-absorbing areas, thus affording to the resulting laminated structure with such concave portions an attractive and realistic three dimensional effect.

The present decorative laminated structure has, alone or in combination with other laminated structures, a wide variety of uses, for example, not only as a material for a ceiling, a floor, a wall and/or an interior decoration of a building, car or ship but also as a decorative material for furniture, fittings, tables, musical instruments and cabinets.

The following examples are given for illustration of the present invention but should not be construed to limit the scope of this invention.

Example 1

Referring to Fig. 18, the areas 12 of the groove portions of a wood grain pattern were gravure-printed, using a dark black ink composition containing as a vehicle a vinyl chloride-vinyl acetate copolymer, on a heat-shrinkable polyvinyl chloride resin sheet 11 (manufactured and sold by Mitsubichi Plastics Ind., Ltd., Japan. Trade name: Hishirex-502. Shrinkage rate: 45—50% at 100°C. Thickness: 40 μ). On the other hand, the pattern 13 of wood grain coordinating with the above-mentioned areas 12 of the groove portions were gravure-printed, using a brown ink composition containing as a vehicle a vinyl chloride-vinyl acetate copolymer, on the heat-shrinkable polyvinyl chloride resin sheet 11. Then, on the back of the heat-shrinkable polyvinyl chloride resin sheet 11 was bonded, using the medium of a vinyl

chloride-vinyl acetate copolymer type adhesive 14, a brown-coloured heat resistant polyvinyl chloride resin sheet 15 (manufactured and sold by Riken Vinyl Ind. Co., Japan. Trade name: Riken Film, Cabinet FC-4648. Thickness: 100 μ) to obtain a laminate.

The thus obtained laminate was irradiated, from the printed surface of the heat-shrinkable polyvinyl chloride resin sheet 11, with near infrared radiation 16 (having a peak of spectral distribution at 1.03 μ) using a bar type infrared ray tungsten filament lamp (manufactured and sold by Ushio Electric Inc., Japan. 200 V, 3000 W) moving perpendicular to its axis at a speed of 16 cm/sec. As a result, the pictures 12 of the groove portions caved in, forming concave portions 17 which were still coloured with the ink as described above. Thus, there was obtained a desired three-dimensionally decorated, laminated structure.

Substantially the same procedure as described above was repeated except that a lined paper with its surface brown-coloured (manufactured and sold by Kohjin Co. Ltd., Japan. Trade name: Kohjin WK-130. Thickness: 230 μ) for use as a wall paper was employed in place of the heat resistant polyvinyl chloride sheet 15. There was obtained a wall paper having a three-dimensionally decorated face.

Moreover, substantially the same procedure as described above was repeated except that the pattern 13 of grains of wood was firstly applied and then the areas 12 of the groove portions of the wood grain were applied. There was obtained a three-dimensionally decorated, laminated structure having a similar effect to the above.

Furthermore, substantially the same procedure as described above was repeated except that there was employed, in place of the heat-shrinkable polyvinyl chloride film, a heat-shrinkable polyvinylidene chloride film, polyester film, polyamide film, polystyrene film, polyethylene film or polypropylene film. There was obtained in each case a three-dimensionally decorated, laminated structure having a similar effect to the above.

Example 2

Referring to Fig. 19, the areas 22 of the groove portions of the wood-grain pattern were offset-printed, using a dark black ink composition containing as a vehicle an alkyd resin on a heat-shrinkable polyvinyl chloride resin sheet 21 (manufactured and sold by Nippon Carbide Ind. Co., Ltd., Japan. Trade name: Hi-S Film #111L3. Shrinkage rate: longitudinally 5%, laterally 50%. Thickness: 40 μ). On the other hand, the pattern 23 of wood-grain coordinating with the above-mentioned areas 22 of the groove portions were offset-printed, using a brown ink composition containing as a vehicle an alkyd resin. Then, on the face printed with the pattern 23 and the pictures 22 of said heat-shrinkable polyvinyl chloride resin sheet 21 was bonded by means of a vinyl chloride resin type adhesive 24, a backing paper 25 for a wall paper with a brown-coloured face (manufactured and sold by Kohjin Co., Ltd., Japan. Trade name: WK-80, 80 g/m^2) to obtain a composite material.

The thus obtained composite material was irradiated from the surface of the heat-shrinkable polyvinyl chloride resin sheet 21 with near infrared radiation 26 (having a peak of spectral distribution at 1.03 μ) using a bar type infrared ray tungsten filament lamp (the same as in Example 1) moving perpendicular to its axis at a speed of 14 cm/sec. As a result, the areas 22 of the duct groove portions caved in, forming concave portions 27 which were coloured with the colour of the pictures 22. Thus, there was obtained a three-dimensionally decorated, laminated structure.

Substantially the same procedure as described above was repeated except that in place of the backing paper 25, a polyester sheet (manufactured and sold by Toray Ind., Inc. Trade name: Lummirror. Thickness: 50 μ) was used to obtain a substantially three-dimensionally decorated laminated structure. In using said polyester sheet, near infrared radiation was irradiated not from the face of the heat-shrinkable film, but from the face of the polyester sheet with the radiation source moving at a speed of 12 cm/sec.

Example 3

Referring to Fig. 20, complete layer was gravure-printed, to form a light brown-coloured layer 32, using a light brown ink composition containing as a vehicle a vinyl chloride resin, on a paper 31 of fine quality (manufactured and sold by Kokusaku Pulp Co., Ltd. Trade name: KRS. 46.5 g/m^2). Then, the areas 33 of the groove portions of the wood grain pattern together with the remainder of the wood grain pattern 34 were printed on the layer 32 by the same printing method employing a similar ink composition. On the thus obtained layer 32 of said paper 31 was bonded by means of a vinyl acetate type resin adhesive 36, a heat-shrinkable polyvinyl chloride resin sheet 35 (manufactured and sold by Mitsubishi Plastics Ind., Ltd., Trade name: Hishirex-MB. Thickness: 30 μ) to obtain a composite material.

Thus obtained composite material was irradiated, from the surface of the heat-shrinkable sheet 35, with near infrared radiation 37, whilst under pressure supplied by a press using a heating type copying machine (manufactured and sold by Duplo Manufacturing Co. Trade name: Duplo Fax F-800), the composite material moving with respect to the copying machine at a speed of 9.8 cm/sec. As a result, there was obtained a three-

dimensionally decorated, laminated structure having concave portions 38 in the heat-shrinkable polyvinyl chloride resin sheet 35 corresponding to the areas 33 of the groove portions.

Example 4

Referring to Fig. 21, the areas 42 of the groove portions of a wood grain pattern were printed on a surface of a heat-shrinkable polypropylene sheet 41 (manufactured and sold by Kohjin Co., Ltd. Trade name: Polyset Thickness: 30 μ) using a black ink composition containing as a vehicle a polyamide resin. On the other hand, the pattern 43 of grains of wood coordinating with the above-mentioned areas 42 was gravure-printed on the other surface of the heat-shrinkable polypropylene sheet 41, using a brown ink composition containing the same vehicle as described above.

Then, to the other face of the heat-shrinkable polypropylene sheet 41 printed with the pattern 43 was bonded by means of an ethylene-vinyl acetate type adhesive 45, a cardboard 44 with a light brown-coloured surface (manufactured and sold by Kohjin Co., Ltd. Trade name: WK-130. 130 g/m^2) to obtain a composite material.

The resultant composite material was irradiated, from the surface of the heat-shrinkable polypropylene sheet 41, with near infrared radiation 46 using the same heating type copying machine as in Example 3 with the composite material moving relative thereto at a speed of 6.3 cm/sec. Thus, there was obtained a three-dimensionally decorated, laminated structure having concave portions 47 corresponding to the above-mentioned pictures 42 of the duct groove portions and coloured with the colour of the areas 42.

The procedure was repeated except that the cardboard 44 was pasted on the face of the heat-shrinkable polypropylene sheet 41 printed with the pictures 42 of the groove portions to obtain a composite material, instead of the other face of the sheet 41 printed with pattern 43. Then the resultant composite material was irradiated, from the surface of the heat-shrinkable sheet 41, with near infrared radiation 46 using the same heating type copying machine as above-mentioned with the composite material moving relative thereto at a speed of 5.5 cm/sec. As a result, there was obtained a three-dimensionally decorated, laminated structure having concave portions in portions of the face of the heat-shrinkable polypropylene sheet 41 corresponding to the areas 42 of the groove portions and coloured with the colour of the areas 42.

Example 5

Referring to Fig. 22, a complete layer was gravure-printed, using a brown type ink composition containing as a vehicle a vinyl chloride-vinyl acetate copolymer resin, to form a brown-coloured layer 52, on a backing paper 51 for a wall paper (manufactured and sold by Kohjin Co., Ltd. Trade name: Kohjin WK-80. 80 g/m^2). Then, on the thus obtained layer 52 of the backing paper 51 was bonded by means of an ethylene-vinyl acetate resin adhesive 54, a heat-shrinkable polyvinyl chloride resin sheet 53 (manufactured and sold by Nippon Carbide Ind. Co. Ltd., Japan, Trade name: Hi-S Film #111L3. Shrinkage rate: longitudinally 5%, laterally 50%. Thickness 40 μ). Then, the areas 55 of the groove portions of a wood grain pattern together with the remainder of the wood grain pattern 56 were printed, by the same method as in Example 1, on the face of the heat-shrinkable polyvinyl chloride resin sheet 53 to obtain a composite material.

The resultant composite material was irradiated, from said printed face, with near infrared radiation 57 employing the same heating type copying machine as in Example 3 with the composite material moving at 10 cm/sec. with respect thereto to obtain a three-dimensionally decorated, laminated structure having the similar concave portions 58 and a similar effect to that obtained in Example 1.

Substantially the same procedure as described above was repeated except that, in place of the above-mentioned heat-shrinkable polyvinyl chloride resin film 53, there was employed a heat-shrinkable polyvinylidene chloride resin film, polyester resin film, polyamide resin film, polystyrene resin film, polyethylene resin film or polypropylene resin to obtain a three-dimensionally decorated, laminated structure having similar concave portions and a similar effect to that obtained in the above.

Moreover, substantially the same procedure was repeated except that, in place of the backing paper 51 for a wall, there was employed a brown-coloured aluminium foil, an asbestos paper or a coloured polyvinyl chloride film to obtain a three-dimensionally decorated, laminated structure having a similar effect to that obtained in the above.

Furthermore, the composite material was, prior to irradiation with radiant heat to form concave portions, coated, on its printed surface, with a coating material comprising a solution of an acrylic resin (manufactured and sold by Röhm und Haas. Trade name: Palaloid B-66) with 5% by weight of silica as a delustering agent (manufactured and sold by Fuji Davison Chem. Co., Ltd. Trade name: Syloid 308) dispersed therein, to form on the composite material a transparent, delustered coating layer. Subsequently, the thus obtained composite material with its surface coated was irradiated, from its coated face, with near infrared radiation employing the

same heating type copying machine as above with the composite material moving at a speed of 11 cm/sec with respect thereto to cause the areas of the groove portions to cave in together with the overlying portion of the transparent coating to form coloured concave portions.

Furthermore, after the composite material without its surface coated was irradiated with heat radiation to form concave portions, the composite material having the concave portions was coated, on its surface, with the same coating material as mentioned above by a spray-coating method. Thus, there was obtained a three-dimensionally decorated, laminated structure with a transparent, delustered topcoat layer.

Example 6

Referring to Fig. 23, a heat-shrinkable, light yellow-coloured polyethylene resin film 61 (manufactured and sold by Dai Nippon Jushi Co., Ltd. Trade name: Polyethylene Shrink Film. Shrinkage rate: longitudinally 50%, laterally 50%. Thickness. 30 μ) and an aluminium foil 62 were bonded by means of a polyester resin adhesive 63 by a dry lamination method. On the heat-shrinkable resin film surface, coloured figures 64 of an arabesque design were offset, gravure-printed using a dark brown ink composition and then the remainder 65 of the surface was offset, gravure-printed, using a brown ink composition containing a similar type vehicle to that of the above-mentioned dark brown ink composition. As a result, there was obtained a composite material. Subsequently, the composite material was irradiated, from its printed face, with near infrared radiation 66 at a distance of 3 cm. from a bar type infrared ray lamp (manufactured and sold by Ushio Electric Inc. 200 V. 1.2 KW) moving at a speed of 10 cm/sec with respect thereto, whereby the coloured figures 64 are caused to cave in and concave portions 67 are formed. Thus, a three-dimensionally decorated, laminated structure with concave portions 67 coloured with the colour of the coloured figures 64 is formed.

Example 7

Referring to Fig. 24, the surface of a paper 71 (manufactured and sold by Tokushu Paper Making Co. Trade name: S-Velum. 80 g/m^2) was coated with a brown-coloured print layer 72 by gravure-printing. On the print layer 72 was gravure-printed a pattern 73 of wood grain, using a brown ink composition. The face of the pattern 73 on the paper 71 was laminated to a heat-shrinkable polyester resin film 74 (manufactured and sold by Mitsubishi Plastics Industries Ltd. Trade name: HS-Diafoil. Thickness. 12 μ) by means of a polyester resin adhesive 75. Then, on the heat-shrinkable film 74 were gravure-printed areas 76 of groove portions of a wood grain pattern coordinating with the wood grain pattern 73 formed on the paper 71, using a dark brown ink composition containing as a vehicle a polyester resin. The resultant composite material was irradiated, from the heat-shrinkable resin film 74 surface, with near infrared radiation 77 supplied from a source moving at a speed of 4.2 cm/sec. with respect to the composite material, whereby the areas 76 of the groove portions were caused to cave in, forming concave portions 78 coloured with the colour of the areas 76.

Alternatively, substantially the same procedure as in the above was repeated except that the areas 76 of the groove portions were formed, prior to lamination, on the heat-shrinkable resin film 74 and then, the heat-shrinkable resin film with the areas 76 was laminated on the paper in such a manner that the areas 74 were coordinated with the pattern 73 of wood grains to produce a composite material. There was obtained a structure having the similar effect to that of the above.

Example 8

Referring to Fig. 25, the areas 82 of the groove portions of the wood grain pattern and the complementary pattern 83 of wood grains were printed, by the same method as in Example 1, on the same heat-shrinkable polyvinyl chloride resin sheet 81 as employed in Example 1. Then, a complete layer was gravure-printed, using a brown ink composition containing as a vehicle a vinyl chloride resin, on the face of the sheet 81 printed with the areas 82 and the pattern 83 thereby to form a brown-coloured layer 84. To the face of the brown-coloured layer 84 on the sheet 81 was laminated, by means of a vinyl chloride adhesive 86, a backing paper 85 for a wall paper (manufactured and sold by Kohjin Co., Ltd., Japan, Trade name: Kohjin W-130. 130 g/m^2) to obtain a composite material.

The resultant composite material was irradiated, from the surface of the heat-shrinkable sheet 81, with near infrared radiation 87 using the same heating type copying machine as used in Example 3 moving at a speed of 9.2 cm/sec with respect thereto. As a result, there was obtained a three-dimensionally decorated, laminated structure having similar concave portions 88 and a similar effect to that obtained in Example 2.

Alternatively, before irradiation, the printed face of the composite material was entirely coated with a matting material comprising a solution of an acrylic resin (manufactured and sold by Röhm and Haas. Trade name: Palaloid B-66) and 5% by weight of silica (manufactured and sold by Fuji Davison Chem. Co., Ltd., Japan. Trade name:

Syloid 308) dispersed therein to form a delustered and transparent top-coat layer having a thickness of about 3 μ. Then, the resultant composite material was irradiated, from said top-coat layer, with near infrared radiation using the same heating type copying machine as mentioned above moving at a speed of 11 cm/sec. As a result, the areas of the groove portions were caused to cave in together with the top-coat layer, to form concave portions which were coloured with the colour of the areas of the groove portions. Thus, there was obtained a desired three-dimensionally decorated, laminated structure.

Alternatively, the printed face of the composite material which had been irradiated without applying the delustered and transparent top-coat layer was, then spray coated with a matting material comprising the same acrylic resin solution and 5% by weight of the above-mentioned silica dispersed therein. As a result, there was obtained a three-dimensionally decorated, laminated structure having a delustered and transparent top-coat layer

In a further variation, a vinyl resin, polyurethane resin or cellulose derivative was employed in place of the above-mentioned acrylic type resin to form a similar top-coat.

Example 9

Referring to Fig. 26, a wood grain pattern 92 was printed, by the printing method and using the ink composition as in Example 1, on a brown-coloured heat resistant polyvinyl chloride sheet 91 as used in Example 1. On the other hand, the areas 94 of the groove portions of the wood grain pattern were printed, by the printing method and using the ink composition of Example 1, on a heat-shrinkable polyvinyl chloride sheet 93 as employed in Example 2.

The heat resistant polyvinyl sheet 91 and the heat-shrinkable sheet 93 were laminated, by means of a vinyl chloride resin adhesive 95, to each other so that the wood grain pattern 92 and the groove portions 94 of the wood grain pattern printed on the respective faces were correctly aligned.

The resultant composite material was irradiated, from the surface of the heat-shrinkable sheet 93, with near infrared radiation 96 using the same heating type copying machine as in Example 3 moving at a speed of 8.3 cm/sec to form a three-dimensionally decorated, laminated structure having a similar effect to that obtained in Example 3.

Example 10

Referring to Fig. 27, the areas 102 of the groove portions of wood grains were gravure-printed, using a dark black ink composition containing as a vehicle a vinyl chloride-vinyl acetate copolymer, on a heat-shrinkable polyvinyl chloride resin sheet 101 (manufactured and sold by Mitsubishi Plastics Ind. Ltd., Japan. Trade name: Hishirex-502, shrinkage rate: laterally 45—50%, Thickness: 40 μ). Then, other areas 102′ of the groove portions of the wood grain pattern were printed by the same method as above, using an ink composition lighter in colour than the above-mentioned dark black ink composition. Further, other areas 102″ of the groove portions of wood grain were printed by the same method as above, using a dark brown ink composition. Then, on the same face of the heat-shrinkable polyvinyl chloride resin sheet 101 was gravure-printed, using a light brown ink composition containing as a vehicle a vinyl chloride-vinyl acetate copolymer, a pattern 103 of wood grains complementary to the above-mentioned areas 102, 102′ and 102″ of the groove portions.

On the other face of the heat-shrinkable polyvinyl chloride resin sheet 101 printed with the pattern 103 and the areas 102, 102′ 102″ was laminated, by means of a vinyl chloride-vinyl acetate copolymer adhesive 104, a creamy-coloured heat-resistant polyvinyl chloride sheet 105 (manufactured and sold by Riken Vinyl Ind. Co., Ltd. Trade name: Riken FC-4648, Thickness. 100 μ) to obtain a composite material.

The resultant composite material was irradiated, from the printed face, with near infrared radiation 106, using a bar type infrared ray tungsten filament lamp as used in Example 1 moving at a speed of 15.5 cm/sec. As a result, the areas 102, 102′, 102″ of the groove portions caved in to form respective concave portions 107, 107′ and 107″ which became stepwise shallower in order and were coloured with colours of the areas 102, 102′ and 102″. Thus, there was obtained a desired three-dimensionally decorated, laminated structure.

Substantially the same procedure as described above was repeated except that a backing paper with a creamy-coloured surface for a wall paper (manufactured and sold by Kohjin Co., Ltd. Trade name: Kohjin WK-130, Thickness: 230 μ) was employed in place of the heat resistant polyvinyl chloride sheet 105. There was obtained a wall paper having a three-dimensionally decorated face.

Moreover, substantially the same procedure as described above was repeated except that the pattern 103 of wood grains was firstly applied and then the areas 102, 102′ and 102″ of the groove portions were applied. There was obtained a three-dimensionally decorated, laminated structure having the similar effect to the above.

Furthermore, substantially the same procedure as described above was repeated except that there was employed, in place of the heat-shrinkable polyvinyl chloride resin sheet, a heat-shrinkable polyvinylidene chloride

sheet, polyester sheet, polyamide sheet, polystyrene sheet, a polyethylene sheet and a polypropylene sheet. There was obtained in each case a three-dimensionally decorated, laminated structure having a similar effect to the above.

Example 11

Referring to Fig. 28, the area 112 of the groove portions of a wood grain pattern was gravure-printed, using black ink composition containing as a vehicle a vinyl chloride-vinyl acetate copolymer, on a heat-shrinkable polyvinyl chloride resin sheet 111 (manufactured and sold by Mutsubishi Plastics Ind. Ltd., Japan. Trade name: Hishirex-502. Shrinkage rate: laterally 45—50% at 100°C. Thickness: 40 μ).

Then, on the back of the heat-shrinkable polyvinyl chloride resin sheet 111 was laminated, by means of a vinyl chloride-vinyl acetate copolymer adhesive 113, a brown-coloured heat resistant polyvinyl chloride resin sheet 114 (manufactured and sold by Riken Ind. Co. Ltd., Japan. Trade name: Riken Film, Cabinet FC-4648. Thickness: 100 μ).

The thus laminated material was irradiated, from the surface of the printed heat-shrinkable polyvinyl chloride resin sheet, with near infrared radiation 115 using the same infrared ray lamp as used in Example 10 moving at a speed of 16 cm/sec. As a result, the picture 112 of the groove portions caved in, thereby forming concave portions 116 which were coloured with the colour of the areas 112.

On the composite material thus formed with the concave portions 116, a pattern 117 of wood grains complementary to the above-mentioned areas 112 of the groove portions was gravure-printed, using a brown ink composition containing as a vehicle a vinyl chloride-vinyl acetate copolymer. Thus, there was obtained a desired three-dimensionally decorated, laminated structure.

Substantially the same procedure as described above was repeated except that a lining paper with its surface brown-coloured (manufactured and sold by Kohjin Co. Ltd., Japan. Trade name: Kohjin WK-130. Thickness: 230 μ) for use as a wall paper and an aluminium foil were separately employed in place of the heat resistant polyvinyl chloride sheet 114. There was obtained in each case a wall paper having a three-dimensionally decorated face.

Furthermore, substantially the same procedure as described above was repeated except that there was employed, in place of the heat-shrinkable polyvinylidene chloride film, a polyester film, a polyamide film, a polystyrene film, a polyethylene film and a propylene film. There was obtained in each case a three-dimensionally decorated, laminated structure having the similar effect to the above.

Example 12

Referring now to Fig. 29, the coloured figure portions 122 of arabesque design were gravure-printed, using a black ink composition containing as a vehicle a vinyl chloride resin, on a heat-shrinkable polyvinyl chloride sheet 121 (manufactured and sold by Mitsubishi Plastics Ind. Ltd., Japan. Trade name: Hishirex-A. Shrinkage rate: laterally 23—28%. Thickness: 40 μ).

Said heat-shrinkable polyvinyl chloride sheet 121 was laminated, by means of a vinyl-chloride-vinyl acetate copolymer adhesive 125, to a heat resistant polyvinyl chloride sheet 124 with its surface light yellow-coloured (manufactured and sold by Kobe Resin Co. Ltd., Japan. Trade name: Bonloid. Thickness: 100) with the printed face of the sheet 121 bonded to the coloured surface of the latter sheet 124.

The resultant laminated material was irradiated, from the surface of the printed heat-shrinkable polyvinyl chloride sheet, with near infrared radiation 126 using a heating type copying machine according to the same process as of Example 11 moving at a speed of 6 cm/sec. As a result, the coloured figure portions 122 caved in, thereby forming concave portions 127 which coincided with said coloured figure portions 122.

On the composite material thus formed with the concave portions 127, the part of the surface 128 coordinating with the above-mentioned coloured figure portions 122 was gravure-printed, using a green ink composition containing as a vehicle a vinyl chloride resin.

Example 13

Referring to Fig. 30, the areas 133 of the groove portions of a wood grain pattern were gravure-printed, using a black ink composition containing as a vehicle a polyamide resin, on a carboard 131 with its surface 132 light brown-coloured (manufactured and sold by Kohjin Co. Ltd., Japan. Trade name: Kohjin WK-130. 130 g/m²).

To said carboard 131 was laminated a heat-shrinkable polypropylene sheet 134 (manufactured and sold by Kohjin Co. Ltd., Japan. Trade name: Polyset. Thickness: 30 μ), by means of an ethylenvinyl acetate copolymer adhesive 135, to obtain a composite material.

The resultant composite material was subjected to irradiation with near infrared radiation 136 using the same heating type copying machine as used in Example 3 moving at a speed of 6 cm/sec. As a result, the heat-shrinkable sheet caved in at its portions corresponding to the pictures 133 of the groove portions of the wood grain pattern, to form concave portions 137. The pattern 138 of

wood grain coordinating with the above-mentioned concave portions 137 was gravure-printed, using a brown ink composition containing the same vehicle as used for the ink composition on said groove portions.

Example 14

Referring to Fig. 31, a heat-shrinkable polyvinyl chloride resin film 141 of a size 10 cm×30 cm (manufactured and sold by Nippon Carbide Inds. Co., Ltd., Japan. Trade name: Hi-S film #120. Heat shrinkage rate: longitudinally 10% and laterally 57% 140°C. Thickness. 30 μ) and a polyvinyl chloride resin sheet 142 (manufactured and sold by Kohjin Co., Ltd., Japan. Trade name: Kohjin WK-130. Thickness: 230 μ) were bonded to each other by means of an ethylene-vinyl acetate copolymer emulsion type adhesive 143 to produce a composite material. Then, the surface of the polyvinyl chloride resin film 141 of the resultant composite material was gravure-printed with a pattern 144 having portions differing from each other in infrared ray absorption rate, using a black ink composition containing a vinyl chloride-vinyl acetate copolymer binder. The printed pattern 144 was composed of repeating rectangles each having a length of 1.0 mm and a width of 0.5 mm. In printing, the gravure-printing pattern having three steps of depths of print pattern, namely 45 μ, 20 μ and 5 μ was employed to form areas differing in infrared ray absorption rate. Subsequently, the resulting composite material was irradiated, for the printed face, with infrared radiation 145, using a heating type copying machine (manufactured and sold by Duplo Manufacturing Co. Trade name: Duplo Fax F-800) moving at a speed of 7.7 cm/sec with a small pressure. As a result, each portion of the printed pattern 144 caved in. The depth of the concave portions 146 varies depending on the temperature due to the infrared absorption of the corresponding portion to the concave portion. Thus, there were obtained concave portions 146 having varied depths. Naturally, the portion having a print pattern depth of 45 μ formed a concave portion 46 having the greatest depth; and the smaller the print pattern depth, the shallower the depth of concave portions. But, all the concave portions having varied depths coordinate with one another.

Example 15

Referring to Fig. 32, a heat-shrinkable polyvinyl chloride resin film 151 (manufactured and sold by Mitsubishi Plastics Industries Ltd. Trade name. Hishirex. Shrinkage rate: laterally 45—50%. Thickness: 40 μ) was gravure-printed with a pattern having portions with varied absorption rates for infrared ray, using the same black ink composition as in Example 14. The heat-shrinkable resin film 151 having the printed pattern 152 and a transparent, rigid polyvinyl chloride resin film 153 (manufactured and sold by Kobe Resin Co., Ltd. Trade name: Bonloid. Thickness. 100 μ) were laminated, by means of a vinyl chloride-vinyl acetate copolymer adhesive, so that the surface of said film 153 was bonded to the face of the printed pattern 152 of the film 151. The resultant composite material was irradiated, from the face of said heat-shrinkable polyvinyl chloride film 151, with infrared radiation 155 whilst under pressure supplied by a press, using the same heating type copying machine as in Example 14 moving at a speed of 5.9 cm/sec, whereby the film 151 caved in to form concave portions 156, 156′ and 156″ which became stepwise shallower at portions of 45 μ, 20 μ and 5 μ in depth. The above-mentioned concave portions 156, 156′ and 156″ were coordinated, in their printed patterns, with one another. Thus, there was obtained a three-dimensionally decorated, laminated structure.

Alternatively, substantially the same procedure as above was repeated except that the irradiation was made from the face of said transparent, rigid polyvinyl chloride film 153 instead of from the face of said heat-shrinkable resin film 151.

Alternatively, the same procedure as above was repeated except that the non-printed face of the heat-shrinkable resin film 151 was laminated to the surface of the transparent, rigid resin film 153.

Example 16

Referring to Fig. 33, in the same manner as in Example 14, on each face of a heat-shrinkable polyvinyl chloride resin film 161 (manufactured and sold by Nippon Carbide Ind. Co., Ltd., Japan. Trade name: HI-S Film, #111L3. Shrinkage rate: 50% in lateral direction, 5% in longitudinal direction. Thickness: 40 μ) was gravure-printed a pattern 162 having portions different in an infrared ray absorption rate, using a black ink composition containing as a vehicle a polyvinyl chloride resin. Then, to one face of said film 161 was laminated a rigid polyvinyl chloride resin film 163 (manufactured and sold by Kobe Resin Co., Ltd., Japan. Trade name: Bonloid. Thickness: 100 μ) by means of a vinyl chloride resin adhesive 164 to obtain a composite material. The resultant composite material was irradiated, from the face of the polyvinyl chloride resin film 161, with near infrared radiation 165, using the same heating type copying machine as employed in Example 14 moving at 5.9 cm/sec, under high pressure supplied by a press. As a result, portions 162 cave in, thereby forming concave portions 166 each of which varied in depth depending on the difference in infrared ray absorption rates of the portions of

said printed pattern 162. The concave portions 166 were coloured with the colours of said printed pattern 162. Alternatively, when the pattern 162 was formed on the opposite face of said film 161, there were formed concave portions 166′ each of which varied in depth depending on the difference of temperature caused by a varied rate of infrared ray absorption of the portion of said printed pattern 162. Each concave portion 166′ coordinated with the printed pattern 162.

Example 17

Referring to Fig. 34, in the same manner and using the same black ink composition as in Example 14, on a heat resistant, brown-coloured polyvinyl chloride resin film 171 was applied a printed pattern 172 having portions differing in infrared ray absorption rate. Then, to the printed pattern 172 of said heat resistant polyvinyl chloride resin film 171 was laminated, by means of a polyvinyl chloride adhesive 174, a heat-shrinkable polyvinyl chloride resin film (manufactured and sold by Mitsubishi Plastics Ind. Ltd., Japan. Trade name: Hishirex-502. Shrinkage rate: 45—50% in lateral direction. Thickness: 40 μ) to obtain a composite material.

The resultant composite material was irradiated, from the face of the heat-shrinkable polyvinyl chloride resin film 173, with infrared radiation 175, using the same heating type copying machine as employed in Example 14 moving at 7.5 cm/sec, under high pressure supplied by a press. As a result, on the outer face of the heat-shrinkable polyvinyl chloride resin film 173 were formed concave portions 176 at portions corresponding to the pictures of the printed pattern 172. The said concave portions differed in depth depending on the difference of temperature caused by variations in the rate of infrared absorption of the portions of said printed pattern 172 and was coordinated with the printed pattern.

Example 18

Referring to Fig. 35, on a heat-shrinkable polyvinyl chloride resin film 181 as in Example 14, were gravure-printed a plurality of geometrical patterns formed of repeating rectangles each having a length of 1.0 mm and a width of 0.5 mm. The depth of the print layer of said printed pattern was 30 μ. The printed patterns 182, 182′ and 182′ ′were coloured black, dark brown and brown, respectively, using an ink composition containing as a vehicle a polyvinyl chloride resin, so as to produce areas so that they are of differing infrared ray absorption rates.

Then, to the polyvinyl chloride resin film 181 with said printed patterns 182, 182′ and 182″ was laminated, by means of a vinyl chloride resin adhesive 184, a transparent, rigid vinyl chloride resin film 183 (thickness: 150 μ).

The resultant composite material was irradiated, using the same heating type copying machine as in Example 15 moving at 4.5 cm/sec, from the face of the printed patterns 182, 182′ and 182″, with infrared radiation whilst under high pressure supplied by a press. As a result, at the black printing pattern 182 was formed the deepest concave portion 186, at the dark brown printed pattern 182′ was formed a concave portion 186′ shallower than the concave portion 186, and at the brown printing pattern 182″ was formed the shallowest concave portion 186″.

Moreover, in the same manner as described above, instead of irradiating from the face of the printed pattern 182, 182′ and 182″, irradiating from the face opposite to the printed patterns 182, 182′ and 182″ whilst a high pressure was applied by a press with the composite material moving at a speed of 4.1 cm/sec. As a result, at a printed pattern portion were formed concave portions each of which varied in depth depending on the difference of temperature caused by variations of the infrared ray absorption of the printed pattern. The concave portions were coloured with colours of said printed patterns. There was obtained a decorative laminated structure having a pattern of embossment.

Example 19

Referring to Fig. 36, areas of the groove portions 192 of a wood grain pattern were gravure-printed, using a black ink composition containing as a vehicle a vinyl chloride-vinyl acetate copolymer, on a heat-shrinkable polyvinyl chloride resin film 191 (manufactured and sold by Mitsubishi Plastics Ind., Ltd., Japan. Trade name: Hishirex-502. Heat shrinkage rate: 45—50% in lateral direction. Thickness: 40 μ). Then, patterns 193 of wood grain coordinating with said groove portions 192 were gravure-printed, using a brown ink composition containing as a vehicle a vinyl chloride-vinyl acetate copolymer, on the heat-shrinkable polyvinyl resin film 191. Then, to the back of the heat-shrinkable polyvinyl chloride resin film 191 with the pattern 193 of wood grain and the groove portion 192 was laminated, by means of a vinyl chloride-vinyl acetate copolymer adhesive 195, a brown-coloured, heat resistant polyvinyl chloride sheet 194 (manufactured and sold by Riken Vinyl Ind., Co., Ltd., Japan. Trade name: FC-4648. Thickness: 100 μ) to obtain a composite material. The resultant composite material was irradiated, from the face of the printed heat-shrinkable polyvinyl chloride resin film, with near infrared radiation 196, using a bar type tungsten filament lamp containing therein a halo-

gen gas (the lamp was manufactured and sold by Iwasaki Electric Co., Ltd., Japan. 200 V, 1.5 KW) moving at 9.2 cm/sec. As a result, the pictures of the groove portion 192 caved in, thereby forming concave portions 197 which were coloured with colours of the areas 192. Thus, there was obtained a three-dimensionally decorated, laminated structure. The resultant decorative laminated structure was subjected to a high temperature heat-fixation treatment in a hot blast furnace 199 at a temperature of 140°C. for 20 seconds, while fixing both edges of said decorative laminated structure by means of clips 198. As a result, the heat-shrinkage rate of the heat-shrinkable poyvinyl chloride resin film 191 was lowered to 15%.

Substantially the same procedure as described above was repeated except that a backing paper with its surface coloured brown (manufactured and sold by Kohjin Co., Ltd., Japan. Trade name: WK-130. Thickness: 230 μ) for use as wall paper was employed in place of the heat resistant polyvinyl chloride sheet 194. There was obtained a wall paper having a three-dimensionally decorated face and having a heat resistant property.

Moreover, substantially the same procedure as described above was repeated except that a transparent polyvinyl chloride film (manufactured and sold by Kobe Resin Co., Ltd., Japan. Trade name. Bonloid. Thickness: 100 μ) was laminated to the base 194 to obtain a composite material, which was irradiated, from the face of the polyvinyl chloride film base 194, with heat radiation, the composite material moving at a speed of 8.3 cm/sec. There was obtained a three-dimensionally decorated, laminated structure having the similar effect to the above.

Furthermore, substantially the same procedure as described above was repeated except that a heat-shrinkable film was firstly bonded to the base and then, on the surface of said heat-shrinkable film were printed the groove portions and the pattern of grains of wood. There was obtained a product having the similar effect to the above.

Example 20

On the surface of a heat-shrinkable polypropylene film (manufactured and sold by Kohjin Co., Ltd., Japan. Trade name: Polyset. Heat shrinkage rate: 10%. Thickness: 30 μ) was gravure-printed, using a black ink composition containing as a vehicle a polyamide resin, coloured figures of an arabesque design. Then, on the back of the heat-shrinkable resin film was gravure-printed, using a green ink composition containing as a vehicle a polyamide resin, a pattern complementing the said coloured figures.

Then, to said complementing pattern side of the heat-shrinkable resin film was laminated a thick paper (manufactured and sold by Kohjin Co., Ltd., Japan. Trade name: WK-130, 130 g/m²) with its surface coloured light yellow, by means of an ethylene-vinyl acetate copolymer adhesive. The resultant composite material was irradiated, from the face of said heat-shrinkable film, with near infrared radiation, using the same heating type copying machine as in Example 14 moving at a speed of 6.3 cm/sec. As a result, the coloured figure portions caved in, thereby forming concave portions which were coloured with colours of said coloured figure portions.

Then, in the same manner as in Example 19, the decorative laminated structure was subjected to a high temperature heat-fixation treatment in a hot blast furnace at a temperature of 160°C. for 12 seconds so as to lower the heat-shrinkage rate thereof. As a result, the heat-shrinkage rate of the heat-shrinkable polypropylene film was lowered to 4%.

Substantially the same procedure was repeated except that the heat-shrinkable resin film, having one surface gradation printed and the other surface printed with a coloured figure, was laminated to a thick paper by its surface carrying the coloured figure print, and was irradiated with radiant heat whilst moving with a speed of 5.5 cm/sec. whereby concave portions were formed on the surface of the heat-shrinkage resin film at its portions corresponding to said coloured figure portions of the back. The resultant laminated structure was subjected to a high temperature heat-stabilisation treatment. There was obtained a three-dimensionally decorated, laminated structure.

Example 21

Referring to Fig. 37, groove portions 212 of wood grain patterns were gravure-printed, using a dark black ink composition containing as a vehicle a polyester resin, on a heat-shrinkable polyester film 211 (manufactured and sold by Mitsubishi Plastics Industries Ltd., Japan. Trade name: HS-Diafoil. Average heat shrinkage rate: 40%. Thickness: 12 μ).

Then, a wood grain pattern 213 complementing the groove portions 212 was gravure-printed on the film, using a brown ink composition containing as a vehicle the same resin as used above. Then, to said film 211 with the wood grain pattern 213 and the groove portions 212 was laminated a stencil paper 214 with its surface coloured brown (manufactured and sold by Tokushu Paper Making Co., Japan. Trade name: S-Velum. 80 g/m²), by means of a polyester resin adhesive 215, to obtain a composite material.

The resultant composite material fed over a heating roll 217 was irradiated, from the face of said heat-shrinkable resin film 211,

with near infrared radiation using a near infrared ray lamp 216 (manufactured and sold by Ushio Electric Inc., Japan. 200 V, 1.2 KW) moving at 6.0 cm/sec. As a result, there were formed concave portions 218 on the surface of the heat-shrinkable film 211 at its portions corresponding to said groove portions 212. Further, in the same manner as in Example 19, said composite material was subjected to a high temperature heat-stabilisation treatment in a hot blast furnace at a temperaure of 240°C. for 30 seconds, while holding both edges thereof. As a result, the heat shrinkage rate of the heat-shrinkable polyester film 211 was lowered to 1%.

Substantially the same procedure as described above was repeated except that, in place of a heat-shrinkable polyester film was employed as a base, a polyester film (manufactured and sold by Toray Inds. Inc., Japan. Trade name: Lumirror. Thickness: 50 μ). The resultant composite material was irradiated with heat radiation whilst moving at a speed of 5.4 cm/sec from the opposite side, to wit, from the face of the polyester film, and then subjected to a heat-stabilisation treatment.

Example 22

The printed face of the composite material obtained in Example 19 was, before applying irradiation, coated with a solution of an acrylic resin (manufactured and sold by Röhm and Haas. Trade name: Palaloid B-66) containing 5% by weight of silica as a matting agent (manufactured and sold by Fuji Davison Chem. Co., Ltd., Japan. Trade name: Syloid 308) dispersed wherein to obtain a composite material having a delustered transparent coating the thickness of which is about 3 μ.

Then, the resultant composite material was irradiated, using the same bar type tungsten filament lamp containing therein halogen gas as in Example 19 moving at 11 cm/sec, with near infrared radiation from the face of the transparent coating of said composite material. As a result, the grooved portions were caved in together with the transparent layer, thereby forming concave portions which were coordinated with the grooved portions and coloured. Thus, there was obtained a structure with its surface delustered. The resultant structure was subjected to a high temperature heat-stabilisation treatment.

Example 23

On the surface of smooth paper (manufactured and sold by Kokusaku Pulp Co., Ltd., Japan. Trade name: KRS. 46.5 g/m^2) was gravure-printed a light brown coloured layer, using a light brown ink composition containing as a vehicle a vinyl chloride resin.

On the thus obtained coloured layer of smooth paper were gravure-printed groove portions of a wood grain pattern and a wood grain pattern, using the same ink composition as in Example 19. Then, to the printed face of said smooth paper was laminated, by means of a vinyl acetate resin adhesive, a heat-shrinkable polyvinylidene chloride resin film (manufactured and sold by Kureha Chemical Ind. Co., Ltd., Japan. Trade name: Krehalon Film. Heat shrinkage rate: 20%. Thickness: 15 μ) to obtain a composite material.

The resultant composite material was irradiated, from the face of the heat-shrinkable film of said composite material, with near infrared radiation, whilst under high pressure supplied by a press, using a heating type copying machine (manufactured and sold by Duplo Manufacturing Co. Trade name: Duplo Fax F-800) moving at 9.8 cm/sec. As a result, on the surface of the heat-shrinkable film were formed concave portions at portions corresponding to the groove portions.

The thus treated composite material was subjected to a high temperature heat-stabilisation treatment in a hot blast furnace at a temperature of 125°C for 15 seconds, while holding both peripheral edges by means of clips. As a result, the heat-shrinkage rate was lowered to 7% and there was obtained a three-dimensionally decorated, laminated structure.

Example 24

Referring to Fig. 38, on the back of a heat-shrinkable polyvinyl resin film 241 (manufactured and sold by Mitsubishi Plastics Industries Ltd., Japan. Trade name: Hishirex-L. Shrinkage rate at 100°C: 3% in longitudinal direction, 25% in lateral direction. Thickness: 40 μ) were gravure-printed the areas 242 of groove portions of a wood grain pattern using a black ink composition containing as a vehicle a vinyl chloride-vinyl acetate copolymer and a pattern 243 of wood grains coordinating with said groove portions 242, using a brown ink composition containing as a vehicle the same copolymer as mentioned above.

To said printed face was laminated, by means of a polyurethane isocyanate adhesive 244, a heat resistant polyvinyl chloride resin sheet 245 coloured light brown (manufactured and sold by Sambow Resin Ind. Co., Ltd., Trade name: KT-6. Thickness: 150 μ). Then, the non-printed surface of said heat-shrinkable polyvinyl chloride resin film 241 was entirely coated with a matting material comprising a solution of a vinyl chloride-vinyl acetate copolymer and 2% by weight of silica (manufactured and sold by Nippon Aerosil Co., Ltd., Japan. Trade name: Aerosil TT-600) dispersed therein. Then, there was obtained a laminated material X having a delustered coating layer 246.

Then, the resultant laminated material X was irradiated, from its delustered coating layer 246 with near infrared radiation 249 at an irradiation distance of 20 mm using a bar type near infrared ray lamp 246 having a reflex mirror (manufactured and sold by Ushio Electric Inc., Japan. 200 V, 3 KW. Peak wave-length: 1.05 μ) moving at 6 mm/min, while holding both edges of the laminated material X with a chain of clips 247 to keep the size thereof unchanged. As a result, the heat-shrinkable polyvinyl chloride resin film 241 caved in at its portions corresponding to the dark brown areas 242 of the groove portions, thereby forming concave portions 250. There was obtained a composite material Y.

Further, the thus obtained composite material Y having the concave portions 250 was subjected to a heat-stabilisation treatment for 6 seconds, using far infrared radiation from a ceramic heater 251 (manufactured and sold by Solidion Co., Ltd., Japan. Trade name: Solidion Influx. 100 V, 600 W. Peak of spectral distribution: 5—50 μ). As a result, there was obtained a three-dimensionally decorated, laminated structure with its surface delustered, having a good heat resistant property.

In the above procedure, instead of forming a delustered coating layer 246, the surface of the heat-shrinkable polyvinyl chloride resin film may be mechanically treated in advance to form fine concavities and convexities thereon, thereby to impart to said film a delustered effect; or the heat-shrinkable polyvinyl chloride resin film may be mixed with fillers such as silica, etc. to impart to said film a delustered effect.

The resultant three-dimensionally decorated, laminated structure was laminated to veneer-core laminated board 252 the thickness of which was 9 mm., by means of an ethylene-vinyl acetate emulsion adhesive (manufactured and sold by Chuo Rika Kogyo Co., Ltd., Japan. Trade name: BA-1120) to obtain a three-dimensionally decorated, laminated structure. Further, on the resultant laminated structure was formed V-shaped grooves projecting through nearly the whole depth of the laminate at desired portions thereof permitting said V-shaped portions to be bent along the grooves and then to be assembled. so as to obtain a cabinet 253.

The above-obtained laminated structure comprising decorated vinyl chloride and veneer-core plywood, which had a thickness of 9 mm. was subjected to a heat-cold repeating test provided for in the Japanese Agricultural Standards (JAS) of Special Plywood. Two test pieces having a square shape of 150 mm by 150 mm were cut off from said laminated structure. The pieces were allowed to stand in a thermostat having a temperature range of 80±3°C for 2 hours and then, allowed to stand in a thermostat having a temperature range of −20 ±3°C for 2 hours. The above procedure was repeated twice and then the test pieces were allowed to stand till the temperature of the test pieces rose to room temperature. As a result, on the surface of said pieces, there was caused no cracking, swelling, wrinkles, discolouration nor weight loss. The size of said pieces remained unchanged. It was found that said structure thoroughly conformed to the standards.

Further, in order to test the heat resistant property of said laminated structure, the same square pieces as employed above were allowed to stand in a thermostat having a temperature range of 80±3°C for one month (720 hours). As a result, there was no change and the laminated structure had an excellent heat resistant property.

WHAT WE CLAIM IS:—

1. A decorative laminated structure having a pattern of concave surface portions, which comprises: a base layer; a sheet; and, contiguous and directly adhered to said sheet, a masking layer having a plurality of radiant portions being formed on the sheet at its portions covered by the heat-absorbing areas.

2. A decorative laminated structure as claimed in claim 1, wherein said sheet having the concave surface portions has formed on its external surface a coating layer for protecting and/or delustering said surface.

3. A decorative laminated structure as claimed in claim 1, wherein said sheet is a uniaxially or biaxially prestretched thermoplastic sheet.

4. A decorative laminated structure as claimed in claim 3, wherein said thermoplastic sheet is a sheet of polyvinyl chloride, polyvinylidene chloride, a polyolefin, polystyrene, a polyester, a polyamide, a polycarbonate or polyvinyl alcohol or a sheet of cellulose or a rubber.

5. A decorative laminated structure as claimed in claim 1, wherein the base layer is adhered to the sheet by means of an adhesive.

6. A decorative laminated structure as claimed in claim 1, wherein said heat-absorbing areas are formed of a heat sensitive ink composition containing a heat-absorbing material.

7. A decorative laminated structure as claimed in claim 6, wherein said heat-absorbing material is a heat-absorbing colouring agent.

8. A decorative laminated structure as claimed in claim 2, wherein said coating layer comprises a resin and a filler.

9. A method of making a decorative laminated structure having a pattern of concave surface portions which comprises forming a laminated composite material comprising a

base layer, a sheet of heat-shrinkable material and a masking layer containing a plurality of heat-absorbing areas, said masking layer being contiguous and directly adhered to said sheet; and irradiating the composite material with radiant heat to cause said sheet at its portions covered by said heat-absorbing areas to shrink so as to form concave surface portions.

10. A method as claimed in claim 9, in which the masking layer is formed on a surface of the sheet and the base layer is laminated to the other surface of the sheet.

11. A method as claimed in claim 9, in which the masking layer is formed on a surface of the sheet and the base layer is laminated to the masking layer.

12. A method as claimed in claim 9, in which the masking layer is formed on a surface of the base layer and the sheet is laminated to the masking layer.

13. A method as claimed in claim 9, in which the sheet is laminated to the base layer, after which the masking layer is formed on the exposed surface of the sheet.

14. A method as claimed in any one of claims 9 to 14, wherein said composite material is provided with a coating layer before irradiation with the radiant heat.

15. A method as claimed in any one of claims 9 to 13, wherein said composite material is provided with a coating layer after irradiation with the radiant heat to form the concave surface portions.

16. A method as claimed in any one of claims 9 to 15, which further comprises subjecting the resulting composite material with the concave surface portions to a heat-stabilisation treatment, thereby imparting thermal stability to the laminated structure.

17. A method as claimed in any one of claims 9 to 13, wherein said sheet is a thermoplastic sheet uniaxially or biaxially stretched.

18. A method as claimed in claim 17, wherein said thermoplastic sheet is a sheet of polyvinyl chloride, polyvinylidene chloride, a polyolefin, a polystyrene, a polyester, a polyamide, a polycarbonate, or polyvinyl alcohol, or a sheet of a cellulose or rubber.

19. A method as claimed in any one of claims 9 to 13, wherein said base layer is adhered to the sheet by means of an adhesive.

20. A method as claimed in any one of claims 9 to 13, wherein said heat-absorbing areas are formed of a heat sensitive ink composition containing a heat absorbing material.

21. A method as claimed in claim 20, wherein said heat absorbing material is a heat absorbing colouring agent.

22. A method as claimed in claim 14 or 15, wherein said coating layer comprises a resin and a filler.

23. A decorative laminated structure substantially as hereinbefore described with reference to the accompanying drawings.

24. A method of making a decorative laminated structure substantially as hereinbefore described with reference to the accompanying drawings.

25. A method of making a decorative laminated structure substantially as described with reference to any of the examples given.

26. A decorative laminated structure made by a method as claimed in any of claims 9 to 22, 24 to 25.

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FIG. 1

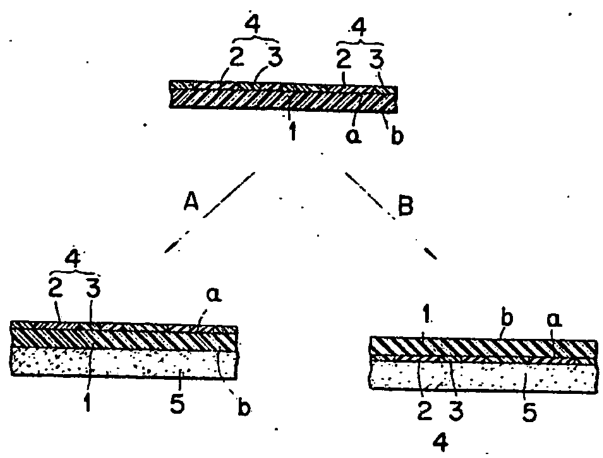


FIG. 2

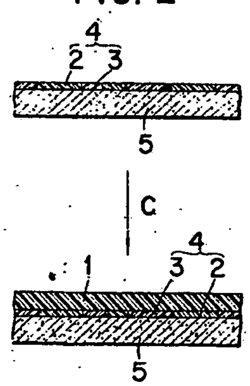


FIG. 3

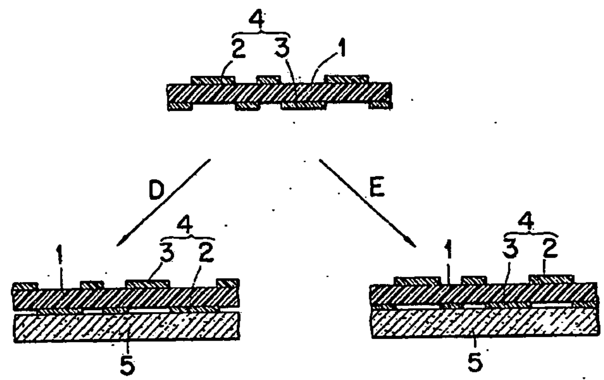


FIG. 4

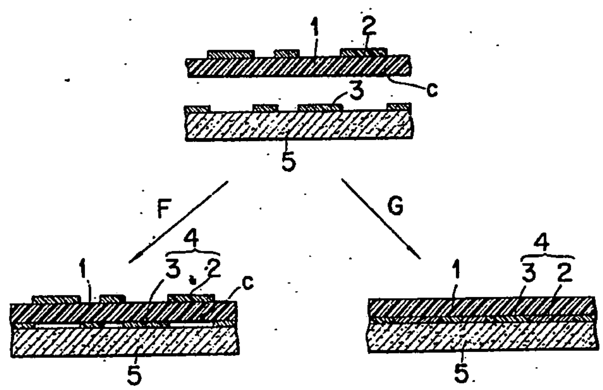


FIG. 5

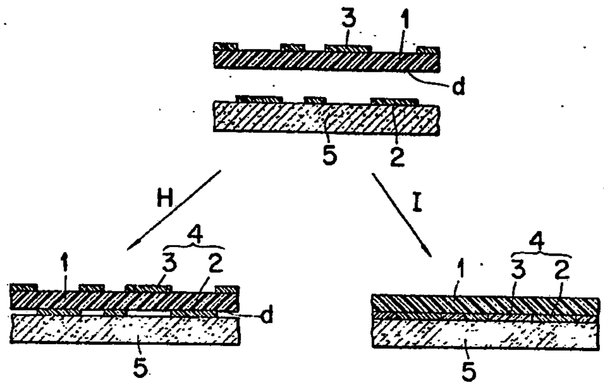
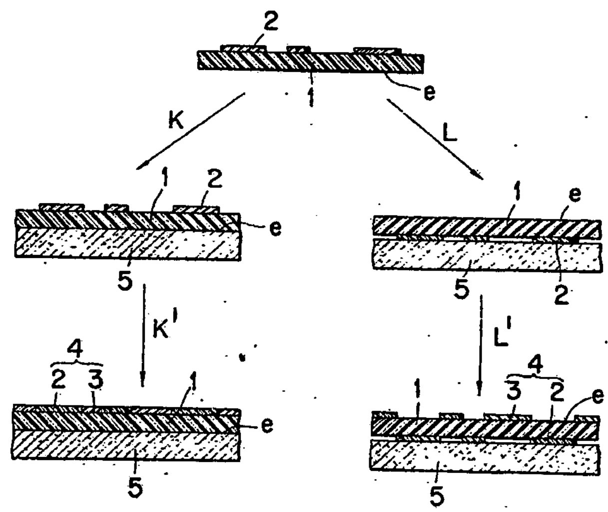


FIG. 7



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Sheet 4

FIG. 6

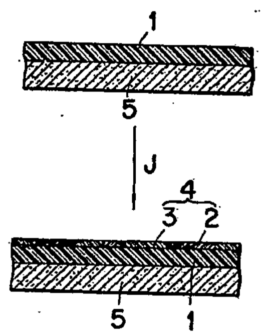


FIG. 8

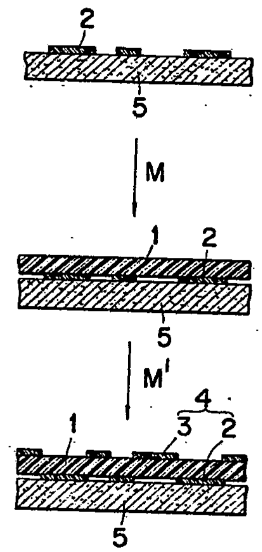


FIG. 9

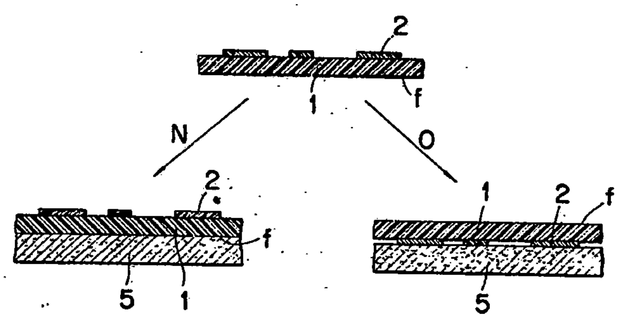


FIG. 10

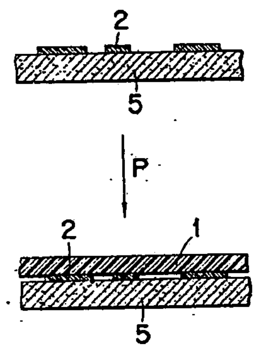


FIG. 11

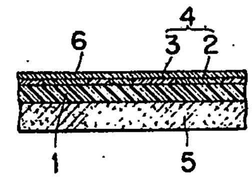


FIG. 12

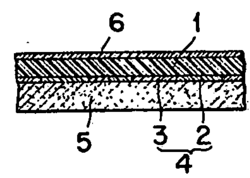


FIG. 13

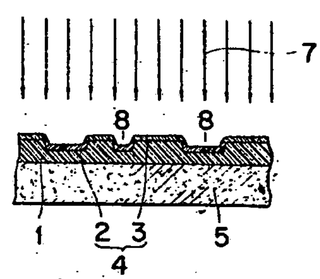
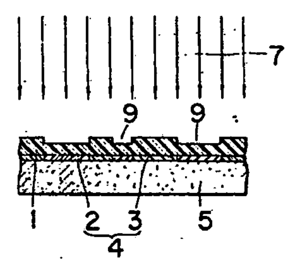


FIG. 14



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Sheet 6

FIG. 15

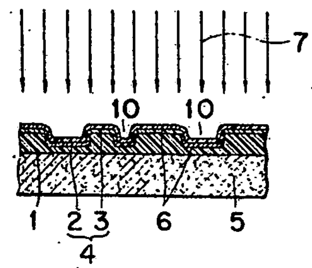


FIG. 16

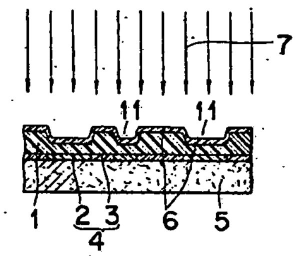


FIG. 17

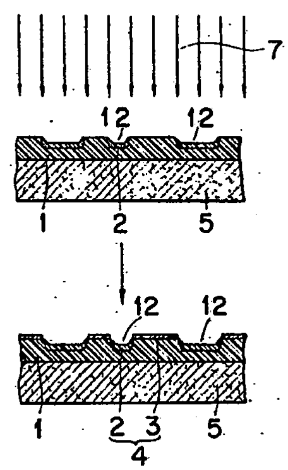


FIG. 18

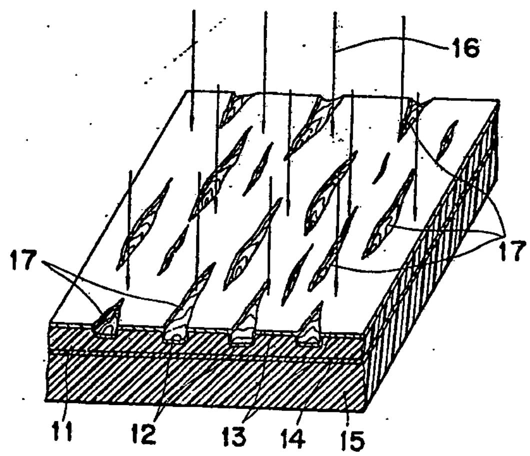


FIG. 19

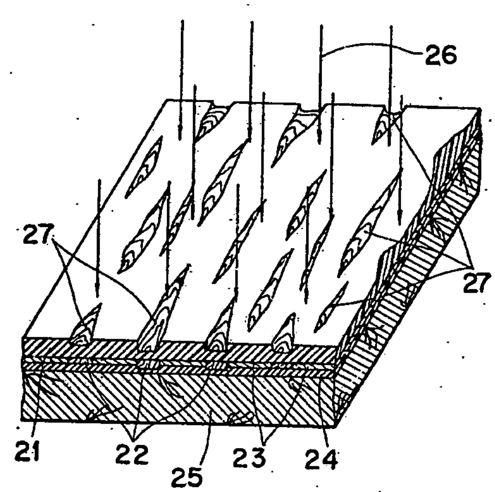


FIG. 20

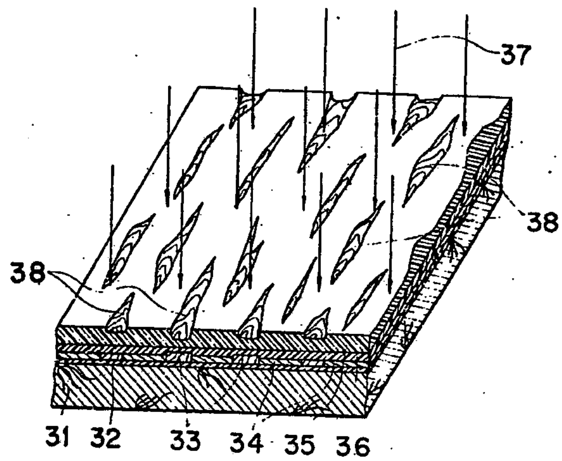


FIG. 21

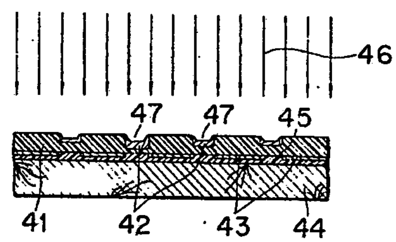


FIG. 22

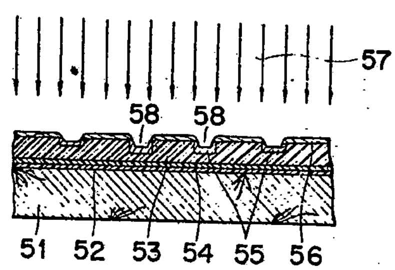


FIG. 23

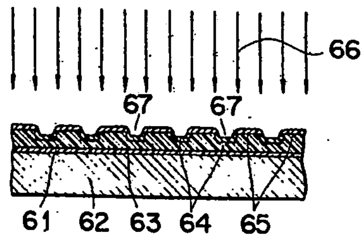


FIG. 26

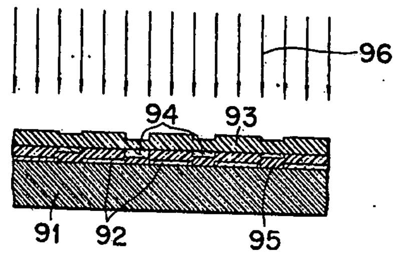


FIG. 24

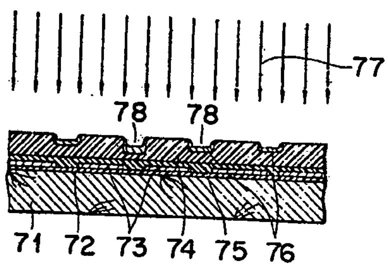


FIG. 27

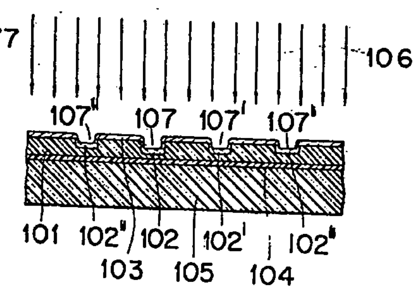
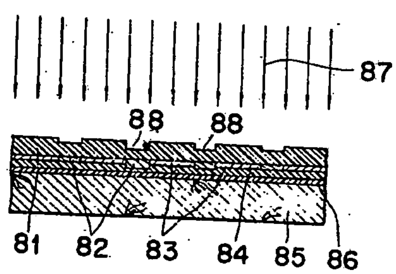


FIG. 25



1413158 COMPLETE SPECIFICATION

13 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 10

FIG. 28

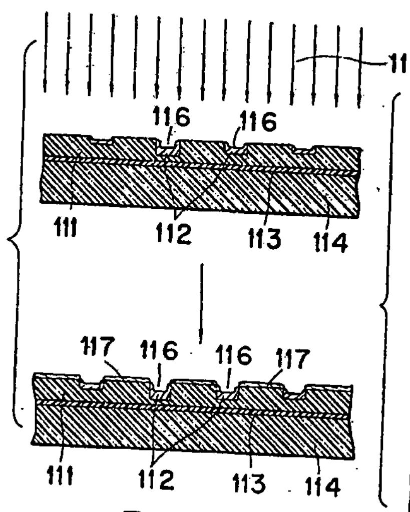


FIG. 29

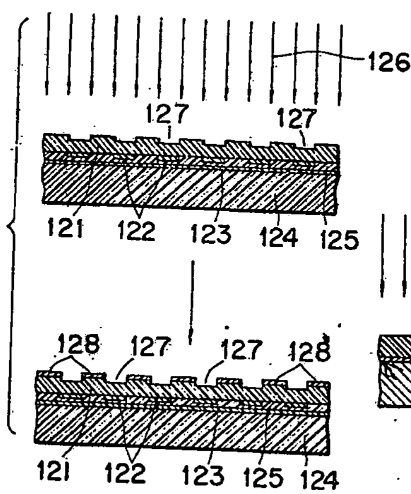


FIG. 30

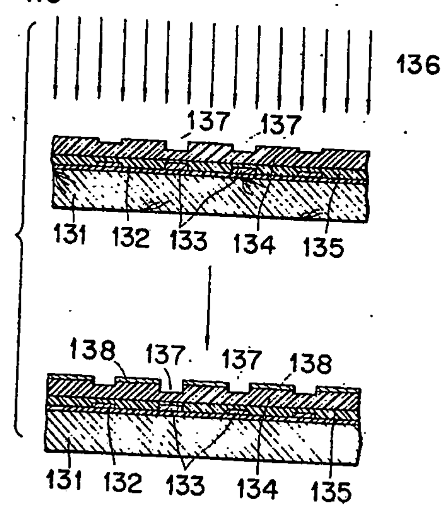


FIG. 31

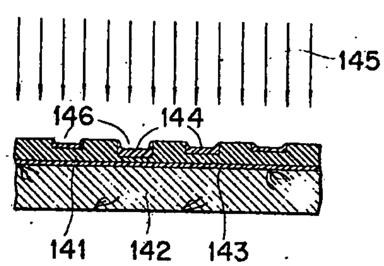


FIG. 32

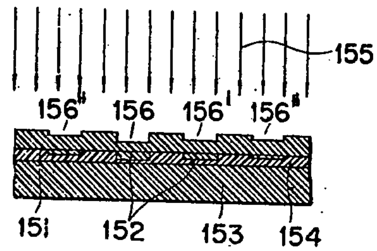


FIG. 34

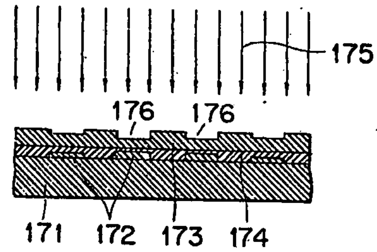


FIG. 35

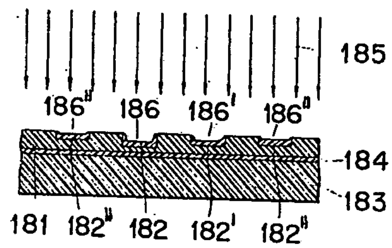


FIG. 33

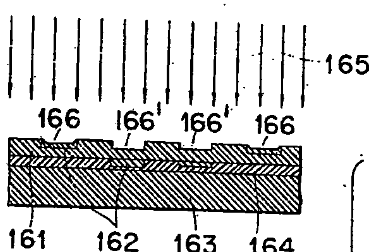


FIG. 37

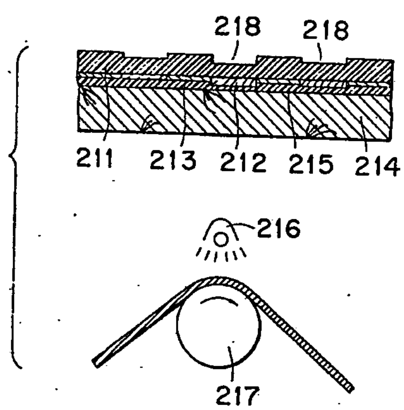


FIG. 36

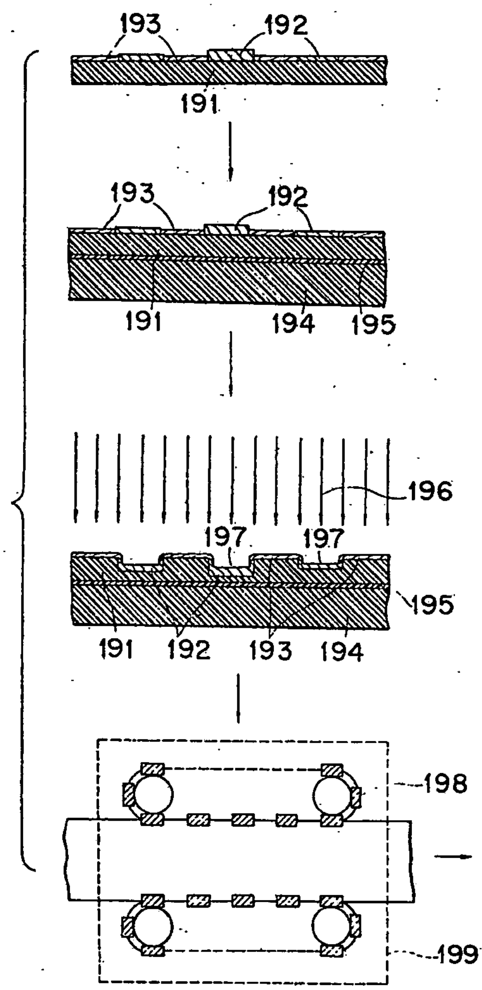

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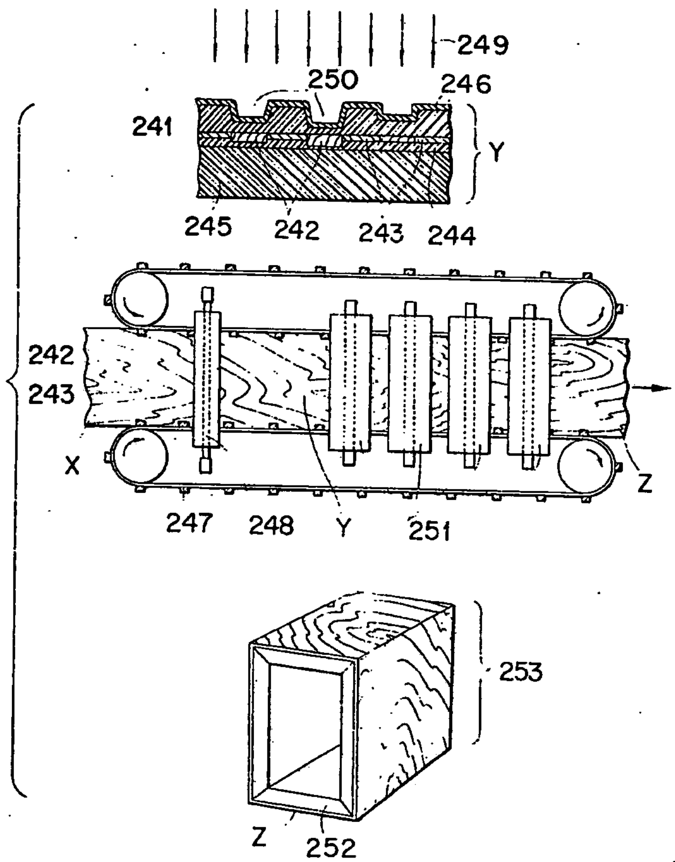
FIG. 38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